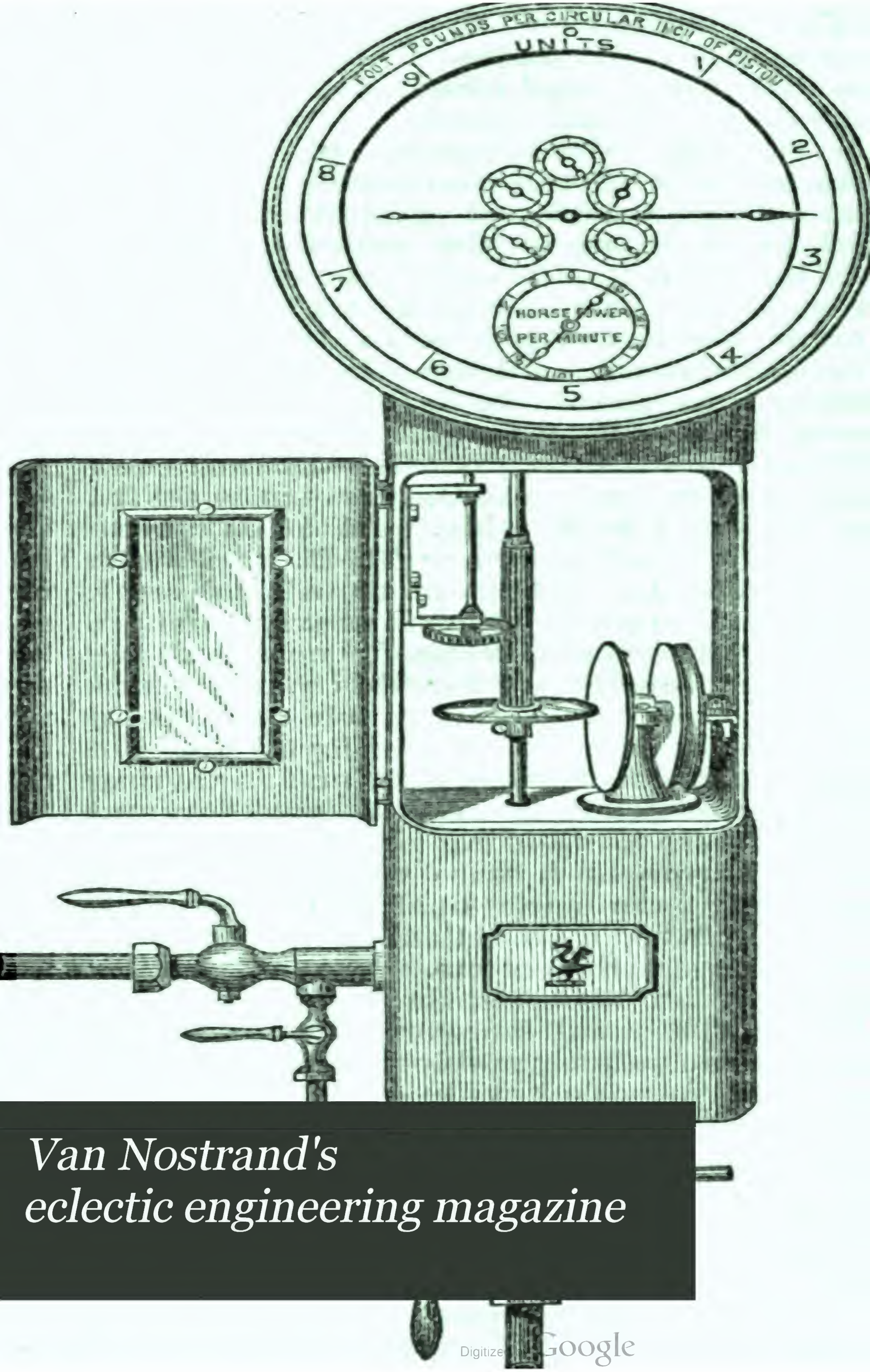

Van Nostrand's eclectic engineering magazine

VAN NOSTRAND'S

ECLECTIC

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VOLUME II.

JANUARY–JUNE,

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VAN NOSTRAND'S ECLECTIC ENGINEERING MAGAZINE.

NO. XIII.—JANUARY, 1870.—VOL. II.

ARCHITECTS AND ENGINEERS.

From "The Builder."

The generalizing tendencies of the present day, the result mainly of the broader analysis of modern science, concur to draw together and assimilate, in many points, pursuits and professions formerly separated by an easily recognized line of demarcation. As we draw nearer in our researches to the first principles in science and art, we come almost insensibly to find things which we had been accustomed to regard as essentially diverse in their nature, resting, in fact, very much upon a common basis; we discover that knowledge and information which have been supposed to bear specially upon one particular occupation, come in usefully also, or even indispensably, in the practice of other pursuits more or less analogous. The primary effect of such discovery is, as we have hinted, to unsettle and confuse the nominal boundaries of professions, a process which is still more accelerated by the rapidity of modern life and the comparatively short time in which everything nowadays is expected and demanded to be done. "That is best which lieth nearest" is the principle adopted by the practical man as well as the artist. The client goes to whomever he thinks will supply him most readily and quickly with what he wants. But the secondary effect of this state of things must necessarily be in the end to narrow the circle of individual practice in any art or profession, to promote the principle of the division of labor, and to break up large and ever widening spheres of labor into smaller subdivisions, so that each practitioner may be able to grasp fully what he professes to do, and to render efficient aid and co-operation towards the grand result to be attained.

It is under such general influences as above indicated, that the two professions named at the head of this article have, at present, got themselves a good deal confounded together in the public mind; which confusion has been, if not initiaed, at least encouraged and stimulated, by sundry members of the engineeering profession, individually or through their recognized journalistic representatives, on the principle, assumed if not stated, that "an architect and an engineer are very much alike — especially an engineer." The distinction between the two professions was formerly sufficiently recognized by every one, and might in broad terms be expressed thus: that the engineer was concerned in providing for transit from one place to another, the architect in erecting buildings *in situ* at the various termini of locomotion. The older engineers made their fame by their canals, their bridges, their roads over impossible places; the architects by their mansions, their town-halls, and public buildings generally. But the advent of that great democratizing agent, steam, for a time very much modified all this. In the first place, the discovery of so new and valua-

ble an agent in locomotion naturally drew everybody's attention, much more than formerly, to the constructions required in connection with locomotion, rather than to those needed for habitation or display. Railways became an end rather than a means, so that in some cases the natural order of things was reversed; and instead of the railway being used as a means of communication between two towns, unimportant towns were made the excuse for a railway, projected and surveyed, if not completed. In such a state of things the engineering profession of course got a long pull, and a strong pull, and a pull altogether, alike upon the purse and the confidence of the public; giving, let it be said, good and strenuous labor in return. Then there were, in connection with railways, such things as terminal and roadside stations to be built; things bearing the semblance of being strictly architectural work, but which, nevertheless, fell largely into the hands of the engineers, as many direful structures up and down the country can and do abundantly testify. Then also, since the time saved in travelling has led inevitably to our much faster rate of living generally, and the demand for the execution of edifices of all kinds on much shorter notice than was once deemed necessary, it has been discovered in some important instances that the engineer, from his constant grappling with tough constructional problems under adverse circumstances, is a readier man in an emergency than the architect; and so there has passed into his hands the superintendence of sundry erections, from time to time, which, if there be anything at all in the architectural profession, certainly ought not to have been built without, at least, the co-operation of an architectural designer. However, the mischief is done now; and that which has in some instances come to pass in practice, has been justified in theory, in certain quarters, with a persistence and an ability which have not been without their effect on the public, who will believe anything if they only hear it often enough, and many of whom are already quite prepared to accept the engineers' own account of themselves, as the persons best qualified to superintend the contriving of all such structures as might, could, or should be erected upon the surface of the earth. This view of the matter is partial and incorrect in itself, discouraging to the student of architecture, and exceedingly pernicious to the student of engineering.

Of course, as we all know, every design must have a structural basis, and therefore knowledge of construction is necessary to the architect, whatever he is engaged upon. It is only when the constructive necessities of a building, or of a structure of any kind, completely override in importance its artistic necessities, or when the constructive problem is so difficult and complicated as to be itself an object of special study, and of the application of abstruse scientific and mechanical principles, directed by a judgment resulting from long practical experience, that the aid of the engineer is really necessary. There are classes of works which belong purely and absolutely to the engineer, and wherein there can scarcely be said to be any scope for architectural embellishment; there are again works, such as ordinary houses, churches, etc., where the only problems really requiring thought and intellect are those of design (including plan) and ornamentation; and there are again works belonging by custom and in their initial form to the engineer, which would yet be susceptible of much embellishment from the hand of the architect; and, conversely, works of which the main object is beauty, but which are erected under structural conditions which demand special engineering skill and science to grapple with them successfully.

And this latter class of works, of what we may term the mixed kind, is much more numerous in the present day than ever it has been hitherto, and is not perhaps likely to become less so. It might seem natural and right that the mere channels of locomotion, of access from one centre to another, should fall solely under the hand of the engineer, as works purely of necessity and for use. And in the old road and canal-making days this was of course the case. But now that the railway system has necessitated so many stopping-places on the road, apart from ordinary towns and villages, where erections of great size are required for the daily use and under the daily sight of many thousands of people (not to speak also of the multitude of roadside stations, important by their number and frequency, if not by their size), it is surely desirable that some special attention should be paid to the

æsthetic beauty of such structures, in addition to their mere constructive strength and fitness. In some cases this has been done, but chiefly in the matter of small roadside stations; the large termini being still left, for the most part, under the sole care of persons whose very education tends to draw their minds completely from considerations of beauty and expressiveness in an edifice, and to develop their faculties on the practical and calculating side only. On the other hand, the demand for the production of very large buildings on very short notice, and sometimes under peculiarly difficult conditions, which has arisen under modern civilization, tends to put the architect in a very different position with regard to the practical requirements of his profession. A Gothic cathedral was a thing elaborated slowly and deliberately, and may have been the result less of any accurate scientific theories than of practical experience attained by men who were constantly engaged on their work, thinking of little else, and who had time to deliberate and to experiment. Now everything is wanted to be turned out of hand by a certain date, and its constructive security must be guaranteed, or the insurance companies will have nothing to say to it. And all this seems to lead us to what we have called the secondary, but inevitable result of the conditions of modern life, viz., the carrying out to a greater extent the principle of the division of labor, and restricting the practice of each profession within closer limits. In other words, we think that not so much a fusion of the professions of engineer and architect is called for, as a co-operation of the members of those professions each in his own strictly defined sphere.

It may be said that we should rather attempt to educate our engineers better in design, our architects more thoroughly in construction, and so dispense with the inconvenience of having two professions to do, as it sometimes seems, the same thing. Our system of education would have to be very much methodized and improved before any such result could be obtained. But we believe the idea is chimerical, except with regard to peculiarly gifted and exceptional individuals. Architectural design, in a high form, rests, as we have frequently urged, upon very subtle and refined principles, not apprehended without considerable study, even by those who have a special gift that way; and the very quality of mind which predisposes a man for this class of study is that which has most antipathy to, sometimes even absolute inability for, mathematical and mechanical studies. "Ah! sir," said William Blake, on being shown some mechanical engravings, "these things we artists *hate*." On the other hand, it cannot be doubted, not only that the highest engineering talent is very often found totally unaccompanied by what we may term æsthetic perception, but that, as before remarked, the very course of an engineer's education tends to draw his mind solely to the consideration of the mechanical properties of material, without any reference to their capability for beauty of form or finish. And the very rapidity of demand in the present day intensifies the importance of this distinction. Were there more time allowed for maturing the design and carrying out the construction of a large building, there might be more chance that one man would be able to provide at once for its constructive and artistic requirements. As it is, except in cases where one of these two classes of requirements is at a minimum, it is next to impossible for one mind to attend properly to things so diverse, and calling into play such a different class of faculties. Where the constructive and the artistic problems are equally balanced, and are each important in themselves, a fully satisfactory result can scarcely be obtained but by co-operation.

We should probably not have much difficulty in recommending such an idea to the consideration, at least, of members of the architectural profession. In some instances within our knowledge, the calling in of an engineer as consulting constructor has been adopted by an architect, and that voluntarily. And there are probably many cases where, in carrying out very large works especially, an architect who was solicitous for his future fame as a designer, would be really glad to be relieved from the onus and responsibility of the thousand and one practical difficulties and dangers to be provided for or guarded against, and have his mind left free to bestow all its faculties on the great end of all architecture, rendering a building a delight instead of a nuisance. We are sorry that we can feel no such confidence, or half-confidence, in the converse

case. The attitude taken by the engineers towards their architectural brethren has too much savored of an antagonistic, or, at least, a kind of "we-can-do-without-you" feeling. When Professor Kerr, some years ago, in a paper read at the Institute, and printed in full in these columns, ventured to advocate something like the same system of co-operation which we have been hinting at, he was answered in an indignant and injured tone by an engigeer correspondent, who assured him that engineers "would not put themselves into architectural harness." No one ever asked them to do anything which ought to be so defined. Those who take this tone, no doubt, think that they evince their superiority by so doing; that they speak from a superior stand-point to that occupied by those half-taught people, the architects. They are quite mistaken. Their arrogance is that, not of knowledge, but of ignorance. But the mischief is, that, from the nature of the case, it is often impossible to convince them of this. Mathematical and mechanical knowledge is a thing that can be defined; and if an architect is deficient in this, his deficiency can easily be proved to him, though he is, of course, open to say, if he choose, that he thinks it of no consequence to him. But if a man is insensible to the difference between beauty and ugliness, between an artistic and expressive and an inartistic and meaningless structure, what can we say? He is insensible, and there is an end. You cannot demonstrate to him, logically, that he has erected a monstrosity upon the earth; for all that he can see, it looks all right, and he does not know what more you can wish for. The absurdity is, that with all this ignorance of and indifference to what constitutes the æsthetic in building, the engineers still seem to have a kind of lurking conception that something called architecture is needed to give the finishing touch to their constructions; and this they set about supplying by the light of nature; that is to say, instead of letting the real construction of their work appear, they mask it behind something which resembles something else which has been done somewhere else by somebody else at some other period, ancient or modern, and which has no conceivable relation to the matter in hand, and then complacently think they have done the architect's work in addition to their own. All that they have really done is to deprive their work of all the solid and satisfactory expression which it might have had as a piece of unadorned construction, and to make it, externally, a meaningless and often hideous sham. Pure constructive provisions, when made on a large scale, will often produce a fine general effect in spite of the engineer. We remember on one occasion being struck by a fine bold outline of a machicolated water-tower seen in the distance from the streets of a provincial town. The machicolations were used for the practical purpose of obtaining a wider area for the tank at the top. We took an opportunity of making a closer inspection of the edifice, and scarcely know how to express the effect it produced upon us. An attempt had been made at what might be called "lunar Gothic;" and every detail in the tower, and the surrounding buildings, was so uncouth, so inconceivably hideous and barbaric, that we stood lost in wonder how any man could possibly have invented such ugliness. Yet this was the work of an engineer eminent in his profession, and who, as we incidentally learnt afterwards, prided himself particularly on the appearance of this very building. He is dead now, and we trust his iniquities are forgiven.

The real remedy for this engineering intrusiveness of barbarism upon us lies with the public. And if the directors of railways and water companies, and such like concerns, could be got to insist upon the introduction of artistic as well as constructive excellence in the great works which their business requires, we might be spared some very painful sights, and even gain some very fine ones, with little or no extra expense. Consider what a fine thing might be made of such a large railway station as that of Crewe, for instance, with its long perspective, if treated with architectural breadth of effect in the general arrangement, and fitness and elegance in details. We see no reason why the engineer should feel insulted at such a proposition. We believe the architects are quite willing to recognize the importance of engineering experience and knowledge, and to avail themselves of it where really desirable. They may surely ask in return that their art should be recognized, and that engineers should be willing to consult the judgment of persons who have studied the art of beauty and expression

in building, which they themselves have paid no attention to. One piece of advice we give the engineers in the meantime: If they still wish to keep clear of the architects altogether, they had better be contented with naked construction, and avoid dabbling in architectural design themselves. They could do nothing which would illustrate more emphatically their need of the architect's assistance.

SURVEYING INSTRUMENTS.

BY E. SHERMAN GOULD, C. E.

NO. III.—THE TRANSIT.

The most important points in the construction of the transit are the fitting and centring of the spindle, and the graduation of the limb and verniers. The graduating limb should be very fine and clear, and converging to the same centre on limb and verniers. The graduation of some instruments is so coarse as to render the precise reading of the vernier indeterminate. When it is remembered that the largest transits in general use have a limb of but 7 ins. in diameter, and that it is therefore from 2 points only 3½ ins. apart that lines are laid off, the necessity of fine work in the centring and graduation will be realized.

Both sides of both verniers should, in all positions, give respectively the same and corresponding readings, *approximately.* It is in the closeness of the approximation that the perfection of the instrument resides. The determining of the degree of approximation depends on the fineness of the graduating lines. The verniers of a coarsely graduated instrument will appear to agree more closely than they really do. If the verniers of a finely cut transit agree to within 10 seconds, it may be pronounced a good instrument. This variation would cause a divergence of about 3 ins. at the distance of 1 mile, between 2 lines of the same bearing turned respectively off the first and second verniers. The true line would be midway between these two erroneous ones. For any thing short of the highest order of work, this is a sufficiently close approximation.

The mere workmanship of a transit has a great deal to do with the accuracy of the operations performed with it. The telescope should "transit" smoothly and steadily, turning easily and yet remaining at any vertical angle without drooping. The different degrees of friction at different angles are often perceptible, and a telescope that stands at one angle will often droop at another. Nothing can be more annoying than this, which is also subversive of perfect accuracy, as the telescope must in such cases be steadied by the hand, which will alter the sight. The cross hairs should be exceedingly fine. The rack and pinion of the object-slide should work smoothly, and without play.

All the screws, etc., constituting the adjusting apparatus should work perfectly, or the surveyor will find great difficulty in adjusting his instrument with precision.

ADJUSTMENTS OF THE TRANSIT.

There are 3 adjustments of the transit which the surveyor can effect himself; they are very simple, but are apt to give considerable trouble to a person attempting them for the first time, on account of the delicacy of manipulation required. These are, *the adjustment of the levels; the adjustment of the line of collimation;* and *the adjustment of the horizontal axis of the telescope.* No matter how carefully an instrument may be handled, it is constantly liable to get out of adjustment, particularly as regards the line of collimation, and unless the adjustment be restored, grave errors will occur. It is therefore indispensable that the surveyor be able to adjust *perfectly* his transit, and familiarize himself with the tests by which any loss of accuracy may be detected. It is supposed that the surveyor is conversant, at least theoretically, with the *modus operandi* of effecting the adjustments; it will not therefore be described here. A good deal of practice is generally requisite to perfect the operator in the mechanical skill necessary to succeed in these manipulations.

The levels afford the means of testing the bearings of the spindle. Thus, after adjusting them on the rotation of the vernier plate, try them on the lower rotation. If the spindle runs truly, the bubbles will still retain their central positions.

The second adjustment, which consists in bringing the line of collimation at right angles to the horizontal axis of the telescope, and the third adjustment, which consists in bringing the horizontal axis of the telescope at right angles to its vertical axis, depend upon each other. That is to say, neither can be performed with perfect accuracy until the other is effected. This difficulty can be parried, if in adjusting for collimation the ground chosen is perfectly level, and the back and fore sights placed exactly equidistant from the instrument. If these conditions are fulfilled, the line of collimation is rendered independent of the third adjustment. In practice, it is, of course, nearly impossible to secure a long stretch of perfectly level ground; the best that can be done is to get it as level as possible, making, if necessary, the sights quite short, and using small objects, such as shawl pins, instead of the chain pins usually employed when the sights are from two to four hundred feet. Another expedient, when ground sufficiently level cannot be procured, if the instrument is provided with a vertical limb, is to take the back and fore sights under the same measured angle of depression, irrespective of distance. It is best, when the third adjustment has been effected, to try the second over again, and reciprocally.

If the line of collimation gets disturbed in the field, and there are no facilities for rectifying it on the spot, set two hubs with the instrument, and place another one, by measurement, exactly between, for the true point. Even when the adjustment is as perfect as it can be made, it is best, in setting hubs at long distances, to verify by rotating the plate; and, in general, it is a good plan in ranging a tangent, to alternate the side of the transit turned forward.

It is assumed in the above adjustment that the tube of the object-glass is correctly centred. If it is not, the instrument must be sent to the maker for rectification. The state of the object-glass is easily ascertained by the line of collimation. If it is out of centre, the line can be adjusted while the glass is kept at the same focus, but if the focus is changed, the line will be found to be out of adjustment.

The final and crucial test of the adjustments is to try the line of collimation on objects at different levels and unequal distances, so as to necessitate a change of focus. If important work is on hand, the instrument should be thus tested before using it.

The limit of accuracy with which a straight line can be ranged with an instrument in perfect adjustment, is the degree of precision with which, in moving from station to station, the point bisected by the cross hairs can be indicated on the hub, the instrument plumbed over this point, and the point last left bisected in sighting back. There are so many causes operating in the field against perfect accuracy in the observations, such as high winds, rain, obstructed sights, the effect on the instrument of changes of temperature, incompetent flag-men, etc., etc., that this limit cannot be fixed. Perhaps it would be safe to say, that on a perfectly clear and still day, on favorable ground, and with thoroughly drilled assistants, the margin of error should not exceed a quarter to half an inch, according to the length of the sights, each time the instrument is moved. It may be doubted if, with the ordinary engineer's transit, of the best construction and in perfect adjustment, it is possible to reduce this limit. Any engineer who has had much regular field practice knows that it can very easily be overstepped.

It is a question, which must be decided according to the character of the work to be done, how far it is expedient to sacrifice time to great precision. The two desiderata of field operations are rapidity and accuracy. At the same time they are antagonistic. Some work demands strict accuracy. In such cases, time must not be taken into account. On the other hand, there are many cases where the surveyor will best serve the interests concerned by not pottering over the infinitesimals.

French Naval School.—We understand that the French Government is about to establish a great central school in Paris for the instruction of youths intended for the navy and mercantile marine. The education will not only include navigation and all connected with it, but the pupils will also receive a thorough commercial education, so as to render them fit for employment in any part of the world.

MANUFACTURE OF PILES, FAGOTS, OR BILLETS OF IRON OR STEEL.

From "The Practical Mechanic's Journal."

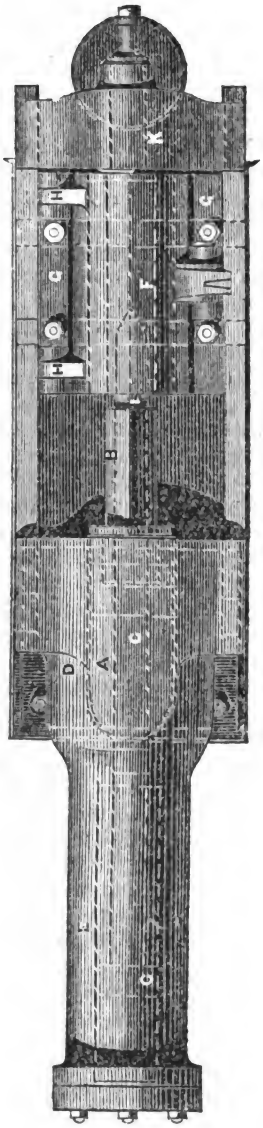
This invention relates to the making of piles, fagots, or billets of any desired shape, from which finished shapes or plain merchant irons or steels can be rolled; also to the making of hollow piles or fagots of iron or steel, from which pipes or columns can be rolled. The essential feature of the invention consists in the forming of iron or steel into piles, fagots, or billets preparatory to rolling, by pressing the metal into forms of the required shape; also in forming iron or steel into hollow piles or billets preparatory to rolling into hollow articles, such as pipes or columns. Various combinations or arrangements of machinery may be employed in manufacturing pressed and moulded piles or fagots as above described, but that which the inventor has found to give the best results up to this date consists of a hydraulic or other powerful press, the ram of which carries a plunger which accurately fits inside a strong metal case or mould of any desired size and transverse section, the sides of such mould being capable of opening on hinges in order to release the compressed and finished pile. The blooms having been placed in the mould, and the sides closed down and secured, the plunger is caused to enter through one end of the mould, which is left open for that purpose, and to forcibly compress by the action of the hydraulic press the metal contained inside the mould, thereby not only expelling the impurities which may be in the bloom, and which escape through the joints in the mould, but causing the metal to be thoroughly consolidated and to take the exact form of the mould. If a hollow pile, a punch or pointed mandrel of the required size and section is fitted into the end of the plunger, and on entering the mould perforates the bloom or blooms, and forces the metal laterally against the sides of the mould. The end of this punch passes through the opposite end of the mould, which has an opening in it just large enough to allow the punch to enter, and this opening is kept closed till the punch arrives by a sliding rod or stopper pressed forward by a counterweight. The punch having penetrated the metal in the mould, the plunger then enters and compresses the metal in a longitudinal direction, after which the plunger and punch are withdrawn. By reversing the action of the press the mould is opened and the finished pile, fagot, or billet, either solid or hollow, as the case may be, is removed in a state ready for rolling.

Fig. 1 of the accompanying engravings is a plan, and Fig. 2 a transverse section of this improved apparatus. A, Fig. 1, represents the piston of a hydraulic steam screw or lever press, which carries a plunger, B, of the same shape as the section of the pile required. This plunger B is hollow, to allow the piston C to move through the same; the said piston passes through the cylinder D into another cylinder E, lying behind and in the same plane as the cylinder D; the piston C is only used when hollow piles are to be made. The plunger B is of the same shape as the internal section of the opening formed by the dies F F F, which are held in place by the frame of the machine G G and by the hinges H H, or other contrivances which permit of the opening of the top form F, which, when open, allows the admission of a number of blooms of puddled iron direct from the puddling furnaces, or of blooms formed from puddled or other iron or steel which have been simultaneously brought up to a welding heat, and placed within these forms; the top being then closed and the power applied to the plunger B, the bulls or blooms will be forced into each other and into the shape of the mould formed by the closing of the dies against each other; the construction of these dies being such that they do not close so tightly as to prevent the expulsion of the impurities which may be in the blooms when placed within the dies.

When it is desired to form a hollow pile, the piston C has a pointed punch I, inserted in the end of the same, and the opposite end of the dies or forms has an opening left in the end, stopping up the forms corresponding to the size of the punch I, which opening is stopped up with a counterweighted stopper K. This stop-

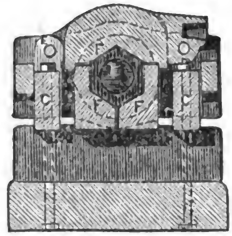
per is forced back when the punch, I, presses against it. The heated bloom being placed within the forms or dies, the pis-

Fig. 1.



ton, C, is moved forward, forcing the punch I through the metal, the rounded or pointed end of the punch causing the metal to be pressed aside rather than driven ahead; when this punch has passed through the metal and forced the stopper, K, back, the plunger, B, being of the shape of the opening formed by the dies, is brought forward, thereby pressing the metal into the shape of the forms and solidifying it around the punch I.

Fig. 2.



When pressed up as far as required, the plunger or piston, C, is withdrawn by opening the escape valve and applying power to the other side of the points, thus withdrawing the punch from the metal. When this is accomplished, the pressure is removed from the plunger B, the dies are opened, and the pile is removed, which consists of a hollow homogeneous mass devoid of seam or opening, into which cinder, scale, or dirt can be forced in the process of reheating.

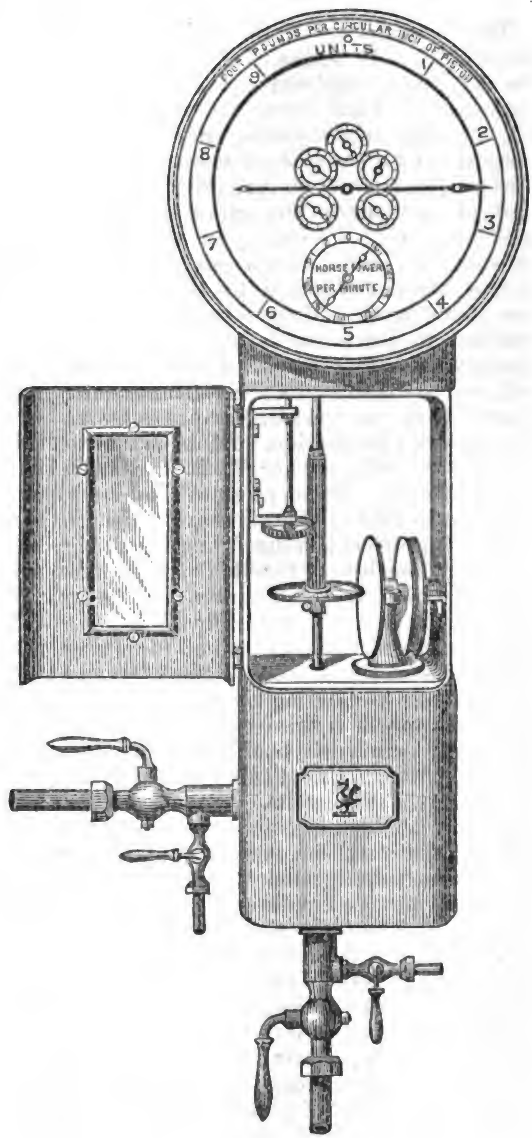
The power applied in either solid or hollow piles should be in proportion to the size and solidity required for the pile or billet. By the removal or insertion of the punch I, either solid or hollow piles may be formed in the same machine.

A Week's Work in Birmingham in its aggregate results is something wonderful. It comprises the fabrication of 14,000,000 pens, 6,000 bedsteads, 7,000 guns, 300,000,000 cut nails, 100,000,000 buttons, 1,000 saddles, 5,000,000 copper or bronze coins, 20,000 pairs of spectacles, 6 tons of papier maché ware, £30,000 worth of jewelry, 4,000 miles of iron and steel wire, 10 tons of pins, 5 tons of hair-pins, hooks and eyes, and eyelets, 130,000 gross of wood screws, 500 tons of nuts, screw-bolts, spikes and rivets, 50 tons of wrought-iron hinges, 350 miles length of wax for vestas, 40 tons of refined metal, 40 tons of German silver, 1,000 dozens of fenders, 3,500 bellows, 1,000 roasting-jacks, 150 sewing-machines, 800 tons of brass and copper wares, besides an almost endless multitude of miscellaneous articles, of which no statistics can be given, but which, like those enumerated, find employment for hundreds and thousands of busy hands, and are destined to supply the manifold wants of humanity from China to Peru.—*The Engineer.*

CONTINUOUS INDICATOR.

By Messrs. Ashton and Storey.

This ingenious instrument was exhibited at the late Manchester Show. It is a steam power meter and continuous indicator, its use being to determine the amount of work done by an engine in any given time. Our engraving shows an elevation of the apparatus. In the lower part is placed a piston and a cylinder, working just as an ordinary indicator. The piston rod actuates a disc wheel, which slides against the face of a vertical rotating disc; both of these are shown in the cut. The horizontal disc actuates a train of mechanism, by which a hand is moved over a dial. When the indicator has no pressure on it, the horizontal wheel, being opposite the centre of the vertical disc, has no motion imparted to it; but the moment the piston rises under the influence of pressure, or falls under that of vacuum, the horizontal wheel has motion imparted to it, and it will move the further in a given time the greater the distance it is removed from the centre of the vertical disc; but this distance is determind by the pressure in the cylinder. The band actuated by the horizontal wheel records foot-pounds per minute, per hour, etc.; and, consequently, the greater the pressure in the cylinder the greater will be the travel of the horizontal disc, and the larger the number of revolutions made in a given time, and the larger the number of foot-pounds registered. The machine shows almost at a glance the power developed during each day or each hour, while diagrams can be taken, as with the ordinary indicator.—*Engineer.*



WITHIN a few years £4,000,000 have been expended by the corporation of the city of London for city improvements.

THE scientific departments at the Royal Arsenal have under investigation the merits of a 37-barrelled rifle said to be an improvement upon Montigny's mitrailleuse, which has been already adopted to some extent by the French Government. This consists of 37 rifle barrels bound together by hoops, the charges for the whole being contained in a movable breech-piece, and the barrels can be discharged singly or together by a turn of the hand. The "machine" has been found to make a good diagram at the targets, almost too good if it is intended to supersede grape shot. The rifling and the bullets are Metfords's and the charge 15 grains.

THE SAINT LOUIS BRIDGE.

From "Engineering."

The construction of the noble bridge, designed by Mr. James B. Eads to cross the Mississippi, and which we have already fully described and illustrated, is proceeding rapidly. Considerable progress has been made with the abutments and piers, and a large amount of preliminary work, and plant is upon the ground. There will be about 20,800 cubic yds. of masonry in each pier, one of which will be 97 ft. in height when completed to 10 ft. above low-water mark, and the other 69 ft., when finished to the same level. In sinking them, 78 ft. and 50 ft. of sand respectively will be passed through. The base of each pier is 82 ft. long, and the eastern is 60 ft., the western 48 ft. wide. At 10 ft. above low-water level, they are 78 ft. in length by 38 ft. wide. These piers will be sunk in caissons, one of which is nearly finished, and the other far advanced; nearly all the necessary machinery for this part of the work is completed, and much of it is in place upon the boats employed for the work. The machinery destined for laying the stone-work is of a novel character, and consists of a scaffolding about 50 ft. high, which supports 6 wire cables 2¼ ins. in diameter. On each boat and upon each cable is placed a traveller for hoisting and transporting the stone. Each traveller can move an 11-ton stone to a distance of 100 ft. They will be worked by hydraulic rams when raising and lowering the stone, and are provided with ordinary gearing for transporting it. Seven sand pumps will be used in the caisson of the eastern pier, and five in the western one, for removing the sand in the descent of the caisson. These pumps are of novel and ingenious construction, and their efficiency has been thoroughly tested, one of them having been used in 40 ft. of water, and found capable of discharging 10 cubic feet of water per hour. The principle is an adaptation of the Giffard injector, water being used instead of steam. A stream of water is forced at a high velocity down through a pipe, and discharged near the same into another pipe in an annular jet, and in an upward direction. The flow of the jet produces a vacuum below it, by which the sand is drawn into another pipe, the lower end of which is in the sand, and the force of the jet drives the sand upwards to the surface of the river as soon as it passes through the annular opening in the jet. The action of this pump is found to be certain, and it will pass gravel as freely as sand, the size of the stones which are discharged being of course regulated by the diameter of the opening. In the pump experimented on, the end of the discharge pipe was inserted to a depth of 19 ft. into the sand, the height of water over the top of the sand being 40 ft. Under these circumstances the action was unfailing, and the vacuum obtained was almost perfect. The pipes used in the pumps will be of 5 in. diameter, and about 2500 ft. will be required. By this arrangement one of the most important difficulties which presented itself with reference to the foundations has been avoided, and the inconveniences and delays attendant upon the use of dredging machines removed. The pumps will be placed on the top of the air chambers of the caissons, the suction pipes extending through the chambers into the sand, telescopic joints on the lower ends allowing the lengths to be extended more or less into the sand as required.

A large portion of the caissons is being made from the wreck of the United States gunboat *Milwaukee*, which was purchased for the Bridge Company, and the plates of her hull cut up for the purpose. The air chambers of both caissons are 9 ft. high, and the sides are formed of ¾ in. plate for the larger, and ⅝ in. for the smaller one. The former is provided with seven air chambers, the latter with five. The area of the chambers is equal to that of the underside of the pier, and the roof has to support the whole weight of the column of masonry from its foundations to above the water level, a height of nearly 100 ft. The roof of the chambers carrying this mass is made of plates ½ in. thick, stiffened above by 13 girders, placed 5 ft. 6 ins. apart. Each girder is 5 ft. deep, and is made of ½ in. plates, with top and bottom chords. The space betwen these will be filled with masonry, and beneath the roof two wooden girders, running in an opposite direction to the iron ones, divide the area of each chamber into three equal parts. Openings in these girders give

communication from one part of the chamber to the other. They are intended to rest upon the sand, and so help to support the mass of masonry above, and relieve the roof of the chamber of a portion of its load. The sides of the chambers are of plate iron, strongly braced to resist the external pressure, and they are, therefore, stiffened with plate-iron brackets. Between the brackets, near the bottom, is placed all round the chamber a timber sill, the underside of which is on the same level as the bottom of the timber girders, and these will also rest upon the sand. A large amount of bearing surface is thus obtained, equal to about 850 sq. ft. This support, the friction of the sand outside the chamber, and the buoyancy of the compressed air within, will together sustain the pier in its gradual descent. In sinking the caisson it will be kept in place by means of 14 large guide piles 3 ft. 6 ins. in diameter, and which carry 10 screws each 25 ft. in length, which will regulate the descent, and secure a perfect equality of motion. The bottom edges of the chamber extend 2 ft. below the underside of the timber sills and guides, and form a cutting edge which will facilitate the sinking, and at the same time prevent any tendency to lateral movement. Before being floated into position, the sides will be extended to a height of 10 ft. above the top of the roof; and as the pier descends, the sides will be heightened.

Up to the first of September last $831,600 had been expended on the work, which now gives employment to about 1500 men. Under the active superintendence of Mr. J. B. Eads, who has recently been enabled to return to St. Louis and again take the undivided responsibility, it is probable that the bridge will advance still more rapidly toward completion.

ON THE MANUFACTURE OF PIPES.

From "The Mechanic's Magazine."

A much greater amount of importance attaches to the material of which pipes for the conveyance of water and other liquids for domestic purposes are made than people generally imagine or admit. The pipes conducting the water-supply from the mains into our houses are for the most part of lead, and this, of all others, is about the most dangerous material that can be used. Lead-poisoning is now so well known to result from the action of certain waters on the pipes that we need not stay here to insist upon the point. We will merely mention, in passing, that the fact that water is poisoned by being brought in contact with lead, has been known for several thousand years. Vitruvius, who flourished B.C. 46, forbade its use for this reason ; whilst Galen, A.D. 130, condemned lead pipe for conducting water because of its injurious effects. We therefore proceed first to notice the various materials of which pipes are made, then to point out their respective defects or demerits, and finally to determine the material which should properly be employed for the purpose. Pipes, in general, are made of wood, iron, lead, copper, tin, stone, and pottery ware. To these substances we may add bitumenized paper, which has recently been introduced as a material for the manufacture of pipes, although we have had samples of this ware by us for nearly twenty years. Wooden pipes are the most economical in first cost, but their many drawbacks have long since led to their disuse, except, perhaps, in some very exceptional cases. They are wanting in strength to resist the pressure of fluids, and are liable to decomposition, decay, leakage, and infection by insects. Water, too, lying long in wooden pipes, becomes putrid from the animal and vegetable matter collected in them. Iron pipes are employed as street mains for conducting water, and sometimes for house purposes, but are troublesome from rust, difficult of repairing, and are liable to break at the joints when a settlement takes place in the surrounding soil.

The process of galvanizing iron pipes has met with considerable favor; but, in the main, we think it will be found to injure the tenacity of the iron, rendering it liable to split under pressure or during frost. It has, moreover, been found to corrode rapidly. At page 59 of "The Mechanic's Magazine" for July 28, 1865, we wrote as follows :—"The question of the best and safest material for the con-

struction of water tanks for ships is being discussed in France. Galvanized iron, it seems, has been employed in the French Navy, but this is condemned by M. Roux, the author of a memoir on the subject, who finds zinc in the water kept in such tanks, and in such quantities that he considers the liquid unfit for domestic use. He recommends for the Imperial Navy water tanks tinned inside." As already observed, lead pipe is commonly used for conducting water from the iron main pipes under the streets into and through buildings. The physical qualities of this pipe admirably adapt it for such use; and in this regard nothing better could be desired. It is easily bent, soldered, and repaired when damaged. These properties have influenced its adoption, notwithstanding a risk, popularly understood and admitted, of injurious results to the health of those employing it. With regard to copper pipes, we need only observe that they are rarely employed except in sugar refineries, breweries, and a few other exceptional cases. Tin pipe is employed for beer, soda-water, condensing worms of stills in the chemist's and pharmaceutist's laboratories, and occasionally for service pipe in dwelling-houses. Stone pipes have been used, and are perfectly safe and wholesome, but difficult to manufacture, and therefore too expensive for use. Pottery ware pipes can only be made in short lengths, are very liable to be broken, and cannot be made to stand a great pressure. It appears, from some ancient buildings, that the Romans sometimes made use of them.

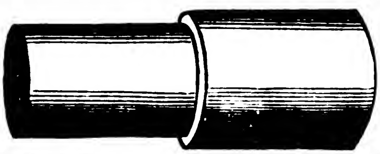
During the past fifty years inventors and manufacturers have bestowed much time and labor upon experiments for making a pipe which would possess the physical qualities of lead, and, at the same time, the chemical properties of tin. These experiments have been induced and stimulated by the advice of chemists and physicians respecting the want of such a pipe, as a substitute for, and to avoid the deleterious effects resulting from the use of, lead pipe. When eminent scientific and professional ability, devoted to the investigation of this subject, testifies to the existence of this evil and to the importance of its correction, it is absurd for individuals to interpose contrary opinions, entirely arbitrary, and based neither upon facts nor intelligence. These opinions are rendered still more absurd in many cases by the efforts they themselves have long been making to accomplish the same object. Among the various plans proposed, one consisted in tinning the ordinary lead pipe inside and outside by drawing it through a bath of molten tin. Another attempt was made to tin lead pipe on the inside by passing it over a hollow mandrel, through which the melted tin was supplied. The method usually employed at present to coat lead pipe is by passing the pipe, as it is formed, through melted tin held around the pipe above the die for the exterior coating, and supplying it for the interior from a perforated cup in the top of the core or mandrel.

This process forms a thin wash of tin which affords no protection against the lead, as an exposure to the atmosphere destroys in a few weeks all appearance of it, and the friction of water passing through the pipe removes it almost immediately. The process, when applied with the utmost care, is also extremely uncertain in the continuity of its action, often leaving spaces entirely untouched by the tin, and sometimes stopping up the pipe completely by the rapid cooling of the tin held in the cup, which then passes off in a lump, a circumstance not unfrequently discovered only when the water or gas is turned on, and thereby incurring the necessity of taking down the ceiling to remedy the fault. The cost of this pipe is from three to six shillings per cwt. more than the common lead pipe, while it possesses no advantage over it. Lead pipe has also been electro-plated with tin, but this was really no improvement upon the methods previously named. Several other plans have been tried, and more or less practised; but, while some have been attended with such difficulties in the manufacture as to make the pipe expensive, all have been imperfect up to the present time.

Now, however, we appear to have a remedy for the evil complained of in Haines' patent lead-encased block-tin pipe, which is being introduced by the manufacturers, Messrs. Walker, Campbell, and Co., of Liverpool. The pipe manufactured by these improvements differs in many respects from any other of its kind. The encased tin tube is made of any thickness desired, perfectly uniform throughout the whole of the pipe, and in coils of any requir-

ed length. The two pipes are made simultaneously, and the metals are so thoroughly united at their surfaces of contact that the junction cannot be disturbed, except by the application of heat sufficient to fuse them. In this peculiarity the pipe comports itself as a homogeneous metal, and yet the two metals composing it remain quite distinct in their mechanical and chemical properties. It has all the pliability and other qualities required by plumbers, which, with its great value as a sanitary agent, warrants the recommendation of it for general use. The accompanying figures afford an idea of the character of this pipe. They show the exact thickness and proportions. Fig. 1 represents a

FIG. 1,

A  B

specimen of lead-encased block-tin pipe, with a portion of the lead or outer pipe, B, removed, so as to show the tin or inside pipe, A.

FIG. 2

FIG. 3.

Figs. 2, 3, 4, and 5 are sections of lead-encased block-tin pipe and lead pipe, tested by hydraulic pressure, and highly spoken of in a report from Mr. A. W. Craven, Chief Engineer of the Croton Aqueduct Department,

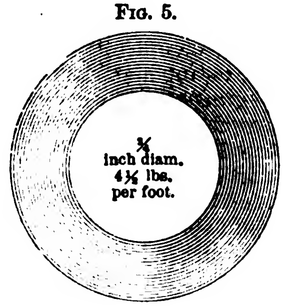
FIG. 4.

ment, in the United States. Experiments relating to the strength of these pipes have been repeatedly made, and comprise tests of all sizes in ordinary use. The pipes were subjected by hydraulic pressure to a bursting strain illustrating their comparative strength.

The section shown in Fig. 2 burst at 1,650 lbs. pressure sq. in., and that in Fig. 3 burst at 1,200 lbs. pressure sq. in.

The section shown in Fig. 4 burst at 1,325 lbs. pressure sq. in., whilst that shown

FIG. 5.



in Fig. 5 burst at 1,150 lbs. pressure sq. in. The heavy black line on the inside of Figs. 2 and 4 represents the tin as enclosed by the lead. From a number of testimonials we have perused, it appears that for conducting gas in public and private buildings this pipe is found to be a most admirable substitute for the heavier lead pipe, or the iron tube, which is so liable to corrosion. The interior surface is highly polished, and entirely free from flaws or inequalities, and thus, presenting no impediment to the flow of water or gas, affords no facility for the accumulation of deposits or tendency to oxidation, which is so frequently the cause of inconvenience or expense in the pipe ordinarily employed for this purpose. With regard to the all-important question of cost, as far as we have been able to ascertain, there is no difference in price between the new tubing and the ordinary lead pipe. It therefore appears a most desirable article, and its superiority in respect of immunity from poisoning leaves no doubt but that it will rapidly come into general favor. It only requires that the public should be made fully aware of the value of the encased tin pipe to insure that, for domestic purposes at least, none other should be used.

THE car shops of the Lake Shore Railroad at Buffalo were lately destroyed by fire. Loss, $300,000.

HEAVY ARTILLERY.

MR. LYNALL THOMAS ON ITS CONSTRUCTION.

From "The Engineer."

A careful student of the recent history of heavy artillery can hardly fail to remark that within the last few years no important innovations in their construction have been introduced. Mr. Fraser appears to have solved much further back the great problem which so long vexed the souls of artillerists, as completely as it can be solved with existing materials of construction. His guns are cheaper than any other guns even approaching them in power; and as regards endurance, it has been demonstrated over and over again, by direct experiment, that no weapons at once so reliable and so terrible have ever been manufactured either for mere experiment or for actual warfare. England possesses the best heavy guns in the world, and of this fact she may be, and as a nation is, proud; but those who have much would have more, and English artillerists still wish for guns which, possessing the same powers of penetrating or smashing structures, whether ships' sides or armored forts, will also possess qualities of greater endurance than any gun yet made is likely to exhibit. We are not content with guns which will fire 300 charges of 70 lbs. of the strongest powder in the world, with shot or shell of proportionate weight. We want guns which will do this and a good deal more; we want guns which will fire at least 1,000 such charges, and such guns in large numbers we do not possess. Government artillerists cannot stand still, yet they are in a cleft stick. To improve on Mr. Fraser is apparently impossible, for the simple reason that Mr. Fraser has, in a sense, got all out of iron and steel that they can give. So artillerists, abandoning the improvement of the gun, have turned their attention to the powder which burned inside it, and we already hear rumors of the commencement of an elaborate and exhaustive inquiry into the composition and form which powder intended for heavy guns should possess. As we cannot strengthen our guns, it is proposed that our powder should be made weaker; and it is by no means impossible that as many millions may be spent on the new investigation as were wasted on the breech-loading scheme introduced by Sir William Armstrong. Such a result would be in every way deplorable, and it is worth while to call attention to some of the facts of the case, Powder *v.* Guns; to examine what has already been done; and to suggest certain points, due attention to which may save public money by directing experiment into proper channels.

On all points connected with the strength of gunpowder, and its action on a gun, the opinions of no artillerists are entitled to very much more consideration than are those of Mr. Lynall Thomas. No private gentleman, we believe, has spent so much money or so much time in experimenting on the phenomena ensuing on the combustion of large and small charges of powder, and we, therefore, welcome the publication of a pamphlet which contains all the results of his experience embodied in an expression of opinions based on these results. Mr. Thomas claims to have been the first to demonstrate the great truth that, as the quantity of powder burned in any gun increases, the strain on the gun augments in an enormously greater proportion than the weight of the powder charge; and from this he deduces certain rules for the construction of guns, which, curiously enough, although ignored by artillerists in theory, apparently regulate the best practice of the day. Indeed, readers of Mr. Thomas's works can scarcely fail to recognize the remarkable correspondence which exists between the laws of construction he has laid down, and the proportions of the strongest existing guns adopted in practice. In order to render Mr. Thomas's views clear, it will be necessary to go back a little way in the history of artillery, and cite a treatise on rifle ordnance published by Mr. Thomas about six years ago. This work contains the reprint of a very able and original paper "On the Nature of the Action of Fired Gunpowder," read before the Royal Society, in December, 1868; and in it Mr. Thomas lays down the important law that the action of a charge in a cannon may be considered of a compound character, consisting, firstly, of an impulse which causes the ball to begin to move with a finite velocity; and, secondly, of the pres-

sure of the fluid generated from the powder. This pressure will be continually augmented by the generation of fresh elastic fluid as the more perfect combustion of the powder takes place, until the whole is completely consumed up to a certain quantity peculiar to the bore of the gun and the quality of the powder used. The whole of the charge may be ignited before the shot is moved, although perfect combustion may not take place.

"The essential point to be considered in the construction of a gun is the general effect produced on the gun by different charges of powder." Mr. Thomas opens his last contribution to the science of artillery with these words, and no one will dispute their truth. He then goes on to show that the accepted theory of the action of powder in guns is contrary to the views he expressed in 1858, and continually compares the action of fired gunpowder to that of a pressure of an elastic fluid within the bore, totally neglecting the percussive action which takes place at the moment of first ignition, which is really the element of destruction as far as the gun is concerned. It follows as a natural consequence, that the strain produced on a gun by the combustion of any given weight of powder, is regarded as simply increasing in the direct ratio of the weight of the charge; and numerous attempts have been made to estimate the force, or, more properly speaking, the pressure exerted within the bore of a gun when a charge was fired. It was assumed that the pressure was identical in a little swivel firing half a pound of powder and a 68 cwt. gun firing ten or twelve pounds, a proper allowance, of course, being made for the difference in the surface acted on by the gases resulting from the combustion of the powder; and, thanks to this theory, all guns were increased in thickness, not in proportion to the weight of the charge, but in relation to the calibre. Thus, the old service 9 lbs. gun, with a bore of 4.2 in., was as nearly as possible half the size in every way except length, of the old 68 lbs. 8 in. gun; and the thickness of metal in the walls of the 68 lbs. gun, measured at a point just in advance of the shot, is as nearly as possible double that of the walls of the 9 lbs. gun. In the former the bore is 8.12 in. in diameter, and the metal about 10 in. thick; in the latter the bore is 4.2 in. and the metal about 5 in. No one appeared to see anything wrong in this, although practice proved that it was wrong, because the charges of powder by no means increased in the ratio of the calibres, and the proof charges of the big guns were very much smaller in proportion than those of the small cannon. Mr. Lynall Thomas showed by an exhaustive series of experiment, that the thickness should augment in a very rapid ratio as compared with the bore, and in modern guns we find that, although his rules, and the experiments from which they were deduced, have been passed over with the silence of neglect, the first have been practically adopted, the thickness of the walls of the modern 9 in. gun being not less than 15.35 in. instead of being about 11.7. It must not be supposed that Mr. Thomas overlooks the fact that increasing the thickness of a gun does not in one sense add to its strength beyond a certain limit. But he holds, and very properly, that mass of metal is absolutely necessary in big guns, not to withstand the mere pressure of the gases, but to take up the percussive shock caused by the initial action of the fired charge, just for the same reason that weight—mere dead weight—is required in the anvil block of a steam hammer.

In further elucidation of these views, we cannot do better than let Mr. Thomas speak for himself. "In the first place (he writes) it must be observed that whilst the shot is traversing the initial space, the rest of the charge is undergoing complete conversion into gas; and when such conversion has taken place, the gas rushes forth in the direction of the axis of the bore. A considerable portion of this gas is driven into, or, more properly, condensed in that space that has just been vacated by the shot; and at this important instant the gun is called upon to sustain the greatest possible strain that is exerted upon it. If the gun be of sufficient strength and thickness to endure the disruptive power of the charge, the chief effect of the intense pressure will be directed towards the removal of the shot. From the above explanation it will be seen that, in order to be able to calculate the different degrees of tension for different guns, we must first endeavor to investigate the mathematical relation subsisting between the initial velocity, the weight of the shot and of the charge, and

the diameter of the bore. As soon as we have determined in what manner the velocity depends upon these known quantities, we shall be able to express in terms of them the volumes into which the gas is condensed; and then it will be seen that the relative strains exerted upon different pieces can by an easy process of mathematical reasoning be expressed as algebraical fractions of certain known quantities."

Mr. Thomas then goes on to quote the results of several experiments more particularly referred to in his paper read in 1858. From these he deduces the four following laws:

(1.) When shot of the same weight and size were subjected to the action of different quantities of powder, fired in chambers of the same diameter, the initial velocities communicated to them were directly as the square roots of the weights of the charges employed. (2.) When shot of different weights were placed upon the same chamber, filled with the same quantity of powder, the initial velocities were inversely as the square roots of the weights of the shot. (3.) When shot of different weights were subjected to the action of different charges of powder, fired in chambers of different depth, but of the same diameter, the initial velocities were directly as the square root of the weight of the powder, and inversely as the square root of the weight of the shot. (4.) *When the diameter of the chamber was increased, the initial velocity was increased (with proportional charges) in the ratio of the square root of the diameter.*

The last of the foregoing is the most important of all, and we believe we only give credit where it is due when we state that it originated solely with Mr. Thomas. The general deductions from the laws we have quoted he formularizes thus:

"The initial velocity is given by $\sqrt{\frac{W'd}{W}}$, the tension or the bursting effect by $\sqrt{\frac{W\,W'}{d^3}}$, and the corroding effect of the pressure by $\sqrt{\frac{LL'}{d}}$.

The charges being supposed to be fired under the same conditions in each gun."

In these formulæ, W is the weight of the shot, W′ the weight of the powder, d the diameter of the bore, L the length of the shot, and L′ the length of the cartridge.

The practical effect of the discovery of the great increase in the force of powder, due to the augmentation in the quantity fired at one time, was sufficiently remarkable. In the days of the 68 lbs. smooth bore, the charge of the 9 lbs. gun was 3 lbs. of powder, which did not greatly tax the gun, while the charge of the 68 lbs. was 16 lbs. only, which taxed it severely. Yet, if the charges had been augmented in the proper ratio to the calibre, the 68 lbs. gun should have burned 24 lbs. of powder; but this it could not do, because it had not metal enough in it. Artillerists did not assign any reason, however, why it could not fire 24 lbs. charges with safety, except the absurd theory that as the size of the casting increased, its absolute strength diminished. Mr. Thomas, as we have seen, proved that the true cause of the apparent weakness of the big gun lay, not in the metal, but in the fact that the big charge exerted a much greater strain on the gun, pound for pound, than the small charge. The true remedy lay in increasing the thickness of the gun, not in the ratio of the augmented calibre, but in that of the force of the powder; and at a very heavy cost to himself, Mr. Thomas produced and tried a steel 7 in. gun, which fired a larger charge (24 lbs.) than had ever before been attempted in a gun of this bore. This gun burst because of a flaw, but not till it had proved how great a stride could be made in the construction of artillery by attention to proper principles.

It is obvious from what we have said, that we hold that the strain exerted on the interior of a gun augments in a very rapid ratio with each increase in the weight of powder fired. That Mr. Thomas practically put this theory forward years ago, no one can dispute; yet we find Sir Wm. Armstrong speaking of the theory as a new discovery, in his opening address, delivered the other day at Newcastle, without the slightest allusion to Mr. Thomas's labors; which is, to say the least, scarcely fair to the last-named gentleman. This is a matter, however, which concerns only Mr. Thomas and Sir William Armstrong. The carrying out of a costly series of experiments on the strength of powder, and the influence exerted by quantity on strain, is a very different matter. It is possible that Mr. Thomas has very nearly, if not quite, done all in this direction that need be done; and it will not be a little vexatious if, at the end of 5 or 6 years, and after the expenditure of enormous sums of money, we find ourselves just in the position in which Mr. Thomas has placed us now. That the best modern guns are unwittingly constructed in accordance

with this theory, and are successful because they are so constructed, he maintains by very weighty arguments. Other claimants to the honor of Mr. Thomas's discovery will possibly start up the moment its value is proved, but with this the nation has really very little to do; truth will, no doubt, prevail, and the honor will rest in the end with the right man. What the nation has to consider is, first, not whether Mr. Thomas's views are original with him or not, but whether they are true; secondly, whether the proposed inquiry into the action of gunpowder will confirm or upset Mr. Thomas's theories; and, thirdly, whether it is worth while to expend a very large sum of money in settling the latter question. It would be as well, we think, that before any considerable expenditure is incurred, Mr. Thomas's theory should undergo a quiet and dispassionate examination at the hands of competent men, with a view to determine how far it is consistent, not only with reason, but with very well known facts in gunnery.

THE GEOLOGICAL RELATIONS OF IRON.

From "The Iron and Coal Trades Review."

[The following paper was read on Monday evening, before the Science Section of the Cleveland Literary and Philosophical Society, Middlesborough, by the President, Mr. Jones]:—

Iron is one of the most widely-diffused of the elementary substances composing the solid crust of the globe, and as this is a locality in which the metal is separated from the ore on an extensive scale, it may be useful and interesting if we endeavor to trace its more important geological relations. The subject of this paper may be considered under two heads—first, the mineral combinations of iron; and, second, the influence of these in the production of geological phenomena. Iron rarely occurs in a native state, but is mostly found in combination with oxygen or sulphur. With the former it produces—(1) protoxide of iron, which is usually found in combination with other substances, forming portions of many igneous rocks, carbonate of iron, etc.; (2) peroxide of iron—known under the names of red hematite, specular iron ore, and brown hematite, which latter is the oxide in a hydrated form; (3) magnetic, or black oxide of iron—a combination of the protoxide and peroxide. With sulphur, iron forms (1) common iron pyrites; (2) white iron pyrites; (3) magnetic pyrites; (4) arsenical pyrites. The metal also occurs in connection with chromium as chrome iron ore; with titanium as ilmenite; with tungsten as wolfram; with silica, and with other substances, forming more or less important combinations, though it is only the commoner forms that play an important part in a geological sense.

We now proceed to consider the relations of iron as a constituent of rock masses. Though there is no particular reason why we should commence our examination with the igneous rocks, as these belong to all geological periods, it may be best if we take this division of rock masses first. In igneous rocks, of whatever age, we find iron is a constant constituent, in some varieties really reaching a comparatively high percentage. Having regard to the relations of the igneous rocks to the internal composition of the globe, it is reasonable to assume that this element is as widely distributed in those impenetrable parts of the globe which science is not likely to open out to human investigation, as it is throughout the igneous and aqueous deposits, which may be studied upon, or near to, the surface. It seems almost certain that the iron now found, in even the oldest sedimentary rocks, was originally derived from the disintegration of the earliest fire-formed rocks, the origin of which, in the present state of our knowledge, is involved in much obscurity.

The lowest sedimentary deposits are comprised in what are termed the Laurentian and Cambrian systems. Here we have a fast thickness of shales, sandstones, and limestones, which are for the most part colored some shade of blue, which indicates the presence of protoxide of iron in the waters in which these ancient rocks were laid down. Our common roofing slates from Cumberland, Westmoreland, and Wales, may be taken as typical examples of the tint which prevails in the system under notice. In

some of the more arenaceous beds of the series, there is a comparative absence of color, probably due to the more rapid formation of these strata, and the consequent wide diffusion of the iron contained in the ocean at that period. At other times, however, very large quantities of iron appear to have been carried into the Cambrian seas, for we find in some places large deposits of oxide of iron in connection with the rocks of this age.

In the Silurian strata the prevailing tint is some shade of blue—that is, in the native condition of the rocks, as all masses which owe their color to protoxide of iron weather into a brown color on exposure to the atmosphere. In the British area a comparatively small amount of iron was present in the ocean of the Silurian period. It is noticeable that about the middle of the system we find a small mass of sandstone, which is colored with red oxide of iron, and resembles, to some extent, one of the divisions of the Old or New Red Sandstone proper. Towards the close of the Ludlow age, when the Silurian seas teemed with the abundant forms of organic life that existed at that time, a comparatively sudden change occurred in the proportion of iron mixed up with the slowly accumulating sediment. What geologists have denominated "passage beds"—indicative of a gradual change from the life forms of the Silurian age to those of the overlying Old Red Sandstone, or Devonian period—are highly colored with the red oxide of iron, and the same general character marks, in a higher or lower degree, the succeeding measures, forming collectively the Old Red and Devonian of England, Scotland, and Ireland.

The carboniferous system, which comes next in ascending order, presents us with immense deposits of limestone and shale, colored by protoxide of iron; a great thickness of coarse sandstone, only slightly colored; and the coal measures proper, the shales of which are not only tinged blue by the lowest oxide of iron, but the quantity of this substance was in some places so abundant as to lead to its being separated from a state of solution and segregated into nodular masses, which have formed most valuable seams of ironstone in Staffordshire, Shropshire, Derbyshire, South Wales, Scotland, and other districts.

The coal period was, again, succeeded by one in which the seas abounded in peroxide of iron, though a gradual change from the one condition to the other evidently occurred, as several local and intermediate stages can be traced through; for instance, the magnesian limestone formation to the Red Sandstones, sands, and other strata that form the upper Permians. But the New Red Sandstone, or Triassic formation, which succeeds it, is eminently pervaded by the red tint due to peroxide of iron.

From the close of the Triassic period those causes which led to the admixture of peroxide of iron with the sedimentary rocks, ceased to operate on an extensive scale, as far as the area of British geology is concerned; and we may, therefore, dismiss the younger rocks with less minuteness of detail. In the South of England the upper Keuper marls are seen gradually shading upwards into the blue shales and limestones of the lias, and, indeed, in this district the change may be noticed, as the sandstone and marl at Leckenby, forming the upper part of the Triassic series, is decidedly tinged with the protoxide instead of with the peroxide of iron. The lower lias is blue throughout, but the middle lias is more arenaceous; and though in places it contains thick deposits of iron in the form of a carbonate, there is only a comparatively small quantity of iron generally diffused through the strata forming this subdivision. The overlying alum shale is colored by protoxide of iron. The oolitic system consists of slightly colored sandstones, with thick deposits of blue clay intervening, so that whilst considerable quantities of protoxide of iron were present at intervals, the hydrated peroxide never occurred in sufficient abundance to leave much trace upon the contemporaneous sediments. In some places deposits of ironstone were formed, but the diffusion of peroxide was due to causes which only came in operation for periods of comparatively short duration.

The same remarks apply to the fluvio-marine beds of the Wealden. The green sand—lower and upper—contains a good deal of hydrated peroxide of iron, both diffused through the mass, and in more concentrated layers; and in some parts the green silicate of iron surrounds the grains of quartz forming the sandstone,

thus giving rise to the name which this formation bears.

The chalk and tertiary beds are not rich in iron, though this material is found more or less to tinge nearly all the strata up to those most recently formed.

The drift deposits which are found filling up hollows, and covering over the regularly stratified rocks on all sides, are naturally colored various shades of red, from having been derived from rocks in which the peroxide of iron largely prevailed. If, for insstance, this country were again to be submerged, the drift produced by the washing of the ocean over the rocks, masses now occurring upon the surface, would evidently be highly colored by being mixed up with the materials derived from the extensive tracts of New and Old Red Sandstone in various parts of the country.

Having now examined the conditions under which iron occurs in the geological series of rocks, we may briefly notice the circumstances which influence the formation of extensive deposits of iron ore. With respect to the masses of red hematic to be found filling up cavities in certain rocks, as, for instance, mountain limestone of the West Coast, and the Devonian limestone of the southwest of England, it appears that at the commencement of the periods when the sea became highly charged with peroxide of iron, the quantity was at first so great as to be deposited in large masses as sediment at the bottom of the ocean, especially in such cavities as might exist in the newly submerged surfaces, but, that the supply of peroxide was afterwards less, or was more widely diffused, and hence was mixed up with an increasingly large proportion of sand and clay, thus reducing the iron to a mere coloring agent. It is easy to see that any deposits of iron ore, formed under such circumstances, are likely to be comparatively free from impurities of an organic origin, as water charged with iron has evidently been fatal, in a great measure, to the existence of animal life; consequently, the deposits of oxide of iron which may be expected to lie at the base of the old and new Red Sandstone formations may also be expected to be free from phosphorus, and other organic impurities. The mountain limestone on the West Coast was under water during the new Red Sandstone period; hence its important deposits of hematite. It remains to be demonstrated how far this submergence of the mountain limestone underneath the Triassic seas extended. My impression is that it will be found that it was only in the western parts of the country that this submergence occurred; though I believe it affected the limestone from Cumberland to the southwest of England, and that in the mountain limestone of North and South Wales, Somerset and Devon, many parts will yield deposits of hematite. I believe also that it will be found that the limestone of South Devon will yield large quantities of good hematite that have been deposited at an earlier age, that is, when the ancient British seas became, for the first time, highly charged with oxide of iron.

With respect to the clay ironstones of the coal measures, their mode of formation was by segregation round some organic nucleus, and hence it necessarily follows that they are more or less mixed up with organic remains, and the substances they would yield. It also follows that this class of ironstone can only be expected to occur in comparatively thin and irregular layers. The mode of formation of the Cleveland ironstone, and of other somewhat similar deposits, is not yet fully understood, though elaborate theories have been invented to account for the occurrence of such extensive masses of ironstone. The main difficulty arises in accounting satisfactorily for the sudden influx of so much iron into the seas of the period when the oolitic iron ores were formed. Whatever the precise circumstances were, it seems clear that what are now thick seams of ironstone were at first only beds of oolitic sand in an unconsolidated form. The infiltration of the iron, and the changes thus produced, probably took place soon after the original deposition of the matrix in which the carbonate of iron is now found. These remarks apply more or less to the iron ores of the secondary formation. The conditions under which these deposits originated, naturally led to their being largely contaminated with organic remains; and it may be expected that all iron ores found in connection with rock formations, yielding fossils, will be comparatively impure.

The limits of this paper will only allow of a cursory treatment of this important subject; but I have endeavored to draw attention to two points, which, perhaps,

may be suggestive to some members of the section who have time to work them out. First, the purest oxides of iron ore are likely to be found in connection with rocks that were submerged during the earlier geological periods; and secondly, the desirability of ascertaining with tolerable accuracy the limits of this submergence.

LONG SPAN BRIDGES.

From "The Mechanics' Magazine."

An allusion was made in our leading article of last week to the fact that engineers are not so prone to indulge in the erection of bridges of large spans as was the practice some years ago. Experience has since demonstrated that when the bearings between the piers reach a certain dimension, the superstructure becomes more expensive than the substructure. It is not generally known that but for the fear of introducing an awkward curve in the line, the bridge over the Menai Straits might have occupied the site of the Swilly instead of the Britannia Rock, and its present maximum spans would have been reduced by nearly 100 ft. But the engineers of the old school had a mortal dread of steep gradients and sharp curves, and considered their absence cheaply purchased by any other sacrifice incurred in the shape of embankments, cuttings, tunnels, bridges, and permanent works of any description. With their limited ideas of one mile radius for the curves, and one in a hundred for the gradients, what would they have thought of engines being manufactured and almost able to "turn in their own length?" and as for gradients, "going up a ladder" is a mild expression for their climbing capabilities! As with the largest span bridge in England so with that in the sister country. The Boyne Viaduct has a maximum span of 260 ft., and carries the Dublin and Drogheda Railway over the valley of that river at some distance from the town. It is now well understood that there was not the slightest necessity for erecting so expensive a bridge, and that the line could have been taken, to more advantage in every sense, nearer the town, where the valley narrows.

There is no disguising the truth that when iron was introduced as a material eminently adapted for the construction of some of the most prominent of the permanent works of a railway, there was a pardonable rivalry among the members of the profession with respect to erecting bridges of large span. Telford led the way both at home and abroad; Stephenson and Brunel followed, and Fairbairn and others brought up the rear. It is clear that every engineer considered it incumbent upon him to prove what he could do with iron, and many structures of that material, hideous in appearance, with proportions in mockery of science, and a distribution of metal betraying an utter and reckless ignorance of the knowledge of strains and strength of materials, attest to the present day the manner in which some of the profession displayed their ability. To such a pitch did their incompetency attain, that, after many fatal proofs of it, a Royal Commission was appointed to inquire into the "Application of iron to railway structures." The whole subject was then thoroughly sifted, the aid of the mathematician was called in to supplement that of the engineer, and the result was the establishment of certain laws and regulations which, if they could not instruct the ignorant, could, at any rate, protect the public from the consequences of their ignorance.

Admitting that bridges of large spans have been erected in positions in which it has been subsequently demonstrated there was no absolute necessity for them to occupy, it must not be understood, on the other hand, that the necessity for a bridge of large span may not arise. There are manifestly numerous localities which roads and railways are ultimately destined to traverse, possessing physical features incapable of being surmounted by any other means. To be of any value, railway intercommunication between any two points must be continuous. The chain must be perfect. The absence of one link is fatal to the whole. Should a ravine, a mountain pass, a chasm, or a hiatus of any kind intervene along the route, it must be bridged, and the size of the span must obviously depend upon the number of piers or supports that it is possible to

erect on the sides and bottom of the gulf. This brings us to the question of the maximum span that it is possible to obtain by any known principle of scientific construction, and just at the present time it has a peculiar interest bearing upon the proposed international bridge over the Channel. We are not about to advocate any particular scheme or discuss the merits of any proposed method for accomplishing the transit between the two shores. Our readers will find full information upon this point in a paper published in our recent numbers. The only method to which our article has any reference is that of M. Boutet; but, were we inclined to advocate the project, we have not the slightest evidence which would enable us to form any opinion of its theoretical or practical feasibility. In the following investigation no notice will be made of stone arches, as their maximum span does not exceed 200 ft., although that principle, being the oldest, has the first claim to consideration. It was, in fact, the original principle proposed by Stephenson upon which to execute the bridging of the Menai Straits. There is no necessity to refer to the reasons why that design was abandoned, because it had to do with other considerations, which reflected not the shadow of doubt respecting the practicability of the project. Neither is there any necessity for our present purpose to advert to the scheme in detail. It is sufficient to state that the maximum span in cast-iron was 360 ft. So far as theoretical construction is concerned, there is no limit to the span of an arch or suspension bridge; but, in spite of this, the former type has almost become obsolete for spans exceeding 200 ft., and the latter has never yet been successfully applied to railway traffic. By railway traffic we do not mean the drawing of carriages, or the crawling of a locomotive over a bridge, but the passage of an express train, or limited mail, at full speed. Here we notice the difference between theory and practice. Stephenson considered that if he increased his cast-iron arch to a span of 460 ft., as he contemplated, the rise of the crown due to expansion and contraction would present a difficulty that he would be unable to provide for. This was no doubt an erroneous impression, as he would have found had not the contingencies imposed by the Admiralty compelled him to abandon the arch principle altogether, and seek for a solution of the novel engineering problem in the adoption of different means. Without inquiring into the relative suitability of cast and wrought iron for the construction of arches, it may be taken for granted that 500 ft. will represent the practical limit to the span of an iron arch.

The next type that deserves consideration is that in which the horizontal strains are resisted by the various members of the structure itself, and a vertical pressure alone transmitted to the supports; and the Menai Bridge certainly ought to be mentioned first. The question therefore is, what is the limit to the span of a tubular bridge? All bridges which are self-containing with respect to the strains exerted upon them, come under the denomination of beams, and the limit of their spans is based upon the fact that the strength is as the square, and the weight as the cube, of their lineal dimensions. The weight of a tubular or solid-sided girder increases far more rapidly with an increase of span than that of the lattice or open web type, in consequence of the large amount of metal required as stiffening irons. About 21 per cent. of the whole material in the Menai Bridge was absorbed in stiffening the sides. The question of determining the maximum possible span of girders becomes very complicated, because by the employment of steel instead of iron, much larger spans could be obtained. At the same time there are no practical examples upon which to base a reliable calculation. It will be safer, then, in the present instance, to deduce our conclusions from what has been already accomplished with a material that is trustworthy, than to hazard conjectures respecting what might be done with another that has not yet been tried. The ultimate span reached by steel would not probably exceed that attained by iron by more than 30 per cent. A tubular girder would not practically exceed the limit of 600 ft. as the maximum span, and if of steel, might reach 800 ft. There is very little doubt that, with the exception of Dr. Fairbairn, the great advocate for solid-sided girders, no engineer would ever again employ the tubular system. A glance at the recently erected railway bridges of large spans, points out unmistakably that the open web principle has superseded the older and the more cumbrous one. Larger spans would be more practicable upon the

open web or lattice principle than upon that of its predecessor. A lattice girder would probably reach a span of 800 ft., if constructed of iron, and of 1000 ft., if steel were employed. Whatever particular form of horizontal girder might be adopted, it may be safely laid down that the maximum span attainable with any material would not be less than 1,000 ft., or, in round numbers, the fifth part of a mile. It must not be considered that we are advocating the economy of bridges of five spans to a mile; we are simply demonstrating their possibility.

The only system to be now alluded to is the suspension, which, so far as mere length of span is concerned, decidedly occupies the first place. Arguing analogically from the size of the existing spans of suspension and horizontal girders, and calculating proportionally, the limit to the span of a suspension girder would be 1,700 ft. The maximum limit, under any circumstances, might be put at 2,000 feet, or about double that attainable by the other type of bridge. Besides these ordinary principles of construction, there are others, such as those of Von Rupert, M. Boutet, and other engineers. With respect to these it should be borne in mind that while on the one hand there are unfortunately no practical data to be guided by, yet there is no valid reason why it may not be possible to achieve larger spans than have hitherto been attempted. The proper line of argument to adopt, and method of testing any of these novel schemes to be employed, is to follow the plan pursued in the case of the Britannia Bridge. Those who believe in the practicability of spans of nearly a mile in length, should have a model constructed to an actual reduced scale of the bridge which is to serve the purpose. It should be broken, put together and broken again, until the best proportions were thus experimentally arrived at. Calculations of the breaking weight and the strains upon the various parts could thus be accurately worked out, and the truth of theoretical formulæ either verified by empirical results, or modified as might be necessary. This is the only plan by which to satisfy professional men and judges of such matters. The mere drawing of a design upon paper, and the results of mathematical investigations alone, are not sufficient to justify any confidence in a novel principle of engineering construction.

The Director-General of the Ordnance and the Committee of Inventions at Woolwich have under trial a bottle cartridge designed by Colonel Boxer. It is intended, if successful, to supersede the ordinary cartridge in use for small-bore breech-loading rifles, which cartridge, being several inches in length, is very liable to injury. The main principle of the invention is to enlarge the chamber of the rifle without interfering with the diameter of the barrel. The cartridge is, therefore, in the shape of a bottle, the apex or neck containing the bullet, while the base consists of the powder, which, being concentrated more than in the elongated cartridge, is theoretically supposed to possess the property of more rapid ignition and consequent increase of force. All the advantages which attach to a "low trajectory" are, therefore, claimed for the invention, which is not so new as is generally supposed, having been introduced some years since in America. We have had by us for the last five years copper-cased bottle-shaped cartridges for the Spencer repeating rifle.

How to Bleach Ivory. — A process for bleaching ivory is given by Dr. Artus. He especially mentions the application to ivory plates for pianoforte keys; but it will of course be applicable to all articles of the material, which is so liable to acquire a disagreeable dark color. The articles are first to be soaked in a solution of carbonate of soda (½ lb. of the crystals to 2 lbs. of water) for a couple of days. They are then to be well rinsed with clean water and afterwards transferred to a solution of ¾ lb. of sulphate of soda in 2 lbs. of water, in which they must remain for 5 or 6 hours. Then, without removing the ivory, a mixture of 1 oz. of hydrochloric acid and 4 oz. of water is to be added, the whole is to be stirred together and the vessel covered up and left for 36 hours. At the end of this time, the solution is poured off and the ivory is to be well washed with water. If it should not have the desired whiteness the process may be repeated. The proportions of solutions we have given above will suffice to bleach 1 lb. of ivory.—*The Workshop.*

APPARATUS FOR MEASURING THE VELOCITY OF SHOT.

DESIGNED BY CAPTAIN W. H. NOBLE, R. A.

From "Engineering."

The instrument consists of two portions: first, the mechanical arrangement for obtaining the extremely high speed of the recording surface, and maintaining that speed uniform; and second, the electric apparatus for registering upon this surface the exact instants of time at which the shot passes certain stated points in the bore of the gun.

The first part of the instrument, for obtaining a very high and uniform speed of the recording surface, consists of a series of six thin metal discs, each 36 in. circumference, fixed at intervals upon a horizontal revolving shaft, which is driven at a very high speed by a heavy descending weight, arranged according to a plan originally proposed by Huyghens, through a train of gearing multiplying 625 times. If the speed of rotation of the discs were got up through the action of the falling weight alone, a very considerable waste of time would be occasioned; and to obviate this inconvenience, a special arrangement is provided for obtaining approximately with great rapidity the required velocity of the discs, by means of a hand-wheel connected temporarily with the gearing. The sound emitted by the rapid rotation of the disc and gearing serves as an indication of the uniformity of speed, a very slight variation in speed being sufficient to alter the acuteness of the sound to an extent that is readily detected by the ear. The actual velocity is ascertained by a clock connected with one of the slower wheels of the train; and the time of making each 5 revolutions of this wheel, or 625 of the discs, is shown correct to $\frac{1}{10}$th of a second by the clock. The speed usually employed in the working of the instrument is about 1,000 in. per second lineal velocity at the circumference of the revolving discs, so that each inch travelled at the circumference of the discs at that speed represents one-thousanth part of a second; and as the inch is subdivided by a vernier and magnifying eye-piece into a thousand parts, a lineal representation at the circumference of the discs is thus obtained of intervals of time as minute as one-millionth of a second. As a minute variation in speed would make a difference in measurement at the circumference of the discs, the uniformity of rotation maintained by the descending weight is tested on each occasion of experiment by three observations—one immediately before, one during, and one immediately after the experiment, the mean of these being taken for the average speed during the experiment. With a little practice, there is no difficulty in managing the instrument so that the discs may rotate either quite uniformly or at a rate very slowly increasing or decreasing; and it is found that the probable error then arising in the determination of the time occupied by 625 revolutions of the discs rarely amounts to so much as $\frac{1}{10}$ of a second, the total time of making each 625 revolutions being about 23 seconds. The uniformity of revolution during each experiment may consequently be considered practically perfect, as the total time of observation in the passage of a projectile along the length of a gun is generally less than one-third of a single revolution of the discs. The maintenance of the speed with so great a degree of uniformity is obtained by means of very great accuracy of workmanship in all parts of the mechanism.

For accomplishing the second portion of the operation, namely, the registering of the exact instants of time which it is desired to determine, the six revolving discs are each covered on the edge with a strip of white paper, and are all in connection with one extremity of each of the secondary wires of six electrical induction coils; the other extremity of each secondary wire, carefully insulated, is brought to a discharger opposite the edge of its corresponding disc, and is fixed so as to be just clear of the revolving disc. When an electric spark is passed from one of the wires to its corresponding revolving disc, a minute hole is perforated in the paper covering on the edge of the disc, marking the point of the disc that was opposite to the wire at the instant of the spark passing; but as the situation of this hole in the paper would be very difficult to find on account of its extreme minuteness, the paper is previously black-

ened over with lampblack, and the position of the hole is then readily seen by a distinct white spot being left on the blackened paper on the edge of the disc, in consequence of the lampblack at that point having been burnt away by the electric spark, so that the white paper is shown beneath. As the points of the six wires at the edge of the discs are all arranged in the same horizontal straight line, parallel with the axis of the revolving discs, an absolutely simultaneous passage of the six electric sparks causes the sparks produced upon the six disks to be all exactly in the

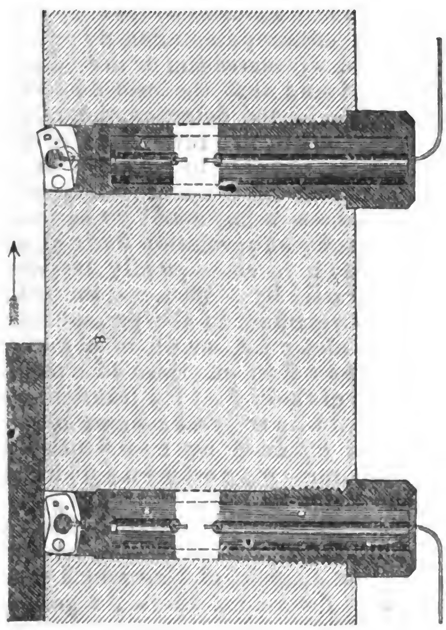
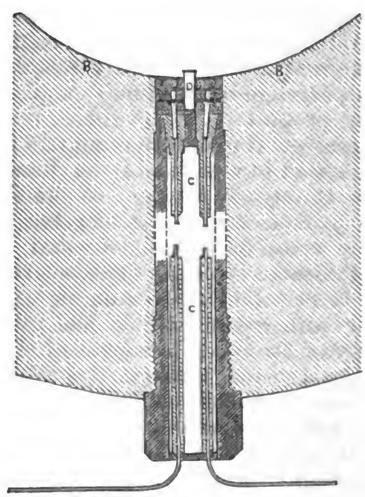


Fig. 1.

same horizontal straight line, at whatever speed the discs may revolve; but any interval of time is represented by a corresponding circumferential distance between the spots on the different discs, this distance being proportionate to the speed at which the discs are revolving. Thus, when the discs are revolving at the circumferential speed of 1,000 in. per second, an interval of $\frac{1}{1000}$th part of a second of time between any two of the sparks causes the spots made upon the two corresponding discs to be separated by a distance of 1 in., measured at the circumference of the discs.

The mode of connecting the primary wires of the induction coils to the bore of the gun in such a manner that an electric current shall be induced, and a spark produced at the instant of the shock, passing each wire in succession, is shown in Figs. 1 and 2, representing a longitudinal and a transverse section of the bore, B, of the gun, along which the shot, A, is moving in the direction of the arrow. A hollow plug, C, is screwed into the side of the gun, carrying at its inner extremity a hinged finger, D, forming a trigger, which is made with an incline at the tail end, projecting slightly within the bore of the gun, as shown in the right side in Figs. 1 and 2. The trigger is held up in this position by the primary wire, which passes in at one side of the plug, C, then through

Fig. 2.



a hole in the trigger, D, and out again at the other side of the plug. When the shot is fired it pushes the trigger, D, outwards, as shown on the left side in Fig. 1, and thereby cuts the wire through, and the consequent breaking of the current in the primary wire induces a current instantaneously in the secondary wire, causing an electric spark at the same instant to pass from the point of the wire to the disc, its passage being marked by the spot left on the paper edge of the disc.

The St. Petersburg Exhibition in 1870.—This exhibition is confined to Russian produce and manufactures; it is national, and not international, as has been stated in some publication. It is to open on the 27th of May, and close on the 27th of July.

HOISTING APPARATUS.

From "The Building News."

To the builder, no contrivances for economizing or facilitating labor are of greater interest than those adapted for raising heavy weights. The advantages obtained by the use of hoisting apparatus come principally under two heads, namely:—concentration of power, and actual saving in the weight to be raised. The concentration of power may be obtained in the case of manual hoists in two ways: either one or two men may lift a weight which many men would otherwise be required for, or a number of men may unite their strength with greater facility than they otherwise could. The saving in the weight actually raised arises chiefly from the fact that the men using any kind of hoisting gear remain stationary; while in other cases they ascend ladders or inclined planes. Thus the weight of the laborer is saved in each "lift" of the apparatus. A further saving can often be effected by counterbalancing the buckets, trucks, or other gear used to contain the material lifted. In using hoists worked by "power," there is the same saving of weight and concentration of power, with the further economy arising from the difference between the cost of steam or water power and manual labor. Amongst hoisting apparatus we have: (1) pulley-blocks of various kinds: (2) differential ditto; (3) windlasses; (4) single and compound crabs; (5) cranes of various kinds; (6) capstans; (7) derricks; and (8) travellers. All these can be wrought by hand, and to most of them steam power has been applied. The amount of ingenuity expended on the improvement of hoisting gear has been very considerable, and the resulting contrivances are very various.

A short history of the progress made, and an explanation of the principles involved in this branch of constructive art, cannot fail to be interesting and profitable to our readers, so much of whose business lies in dealing with the proper raising of weights. In order to treat the subject in an intelligible manner, it will be necessary to commence with a consideration of the mechanical principles on which all are alike founded.

It must be distinctly borne in mind that no mechanical contrivance can create power, or increase it; it can only be modified in various ways. For convenience of illustration let us take 1 lb., 1 ft., and 1 minute, as standards respectively of weight, height, and time. It is evident that if 1 lb. be raised through a height of 1 ft., a certain amount of work is done, no matter in what length of time. It is equally evident that a proportionate amount of power must be exerted to do this work, and the absolute amount of such power is also independent of the time taken to do the work. Further, supposing 10 lbs. be raised in place of 1 lb., also through 1 ft. in height, 10 times the work is done; and if 1 lb. be raised 10 ft., it follows equally that 10 times as much work is done as in the first case. We arrive therefore at this first principle—that the work done is in direct proportion to the weight raised, and in a like proportion to the height through which it is raised. We see also that since the raising of any given weight to any given height represents always the same amount of work, and therefore the same amount of power, the work done and the power consumed are alike independent of the question of absolute time. But still it is evident that, as the work must be accomplished in some portion of time, the element of duration and speed must be considered. This seems almost to lead to a paradox, namely, that power is at once dependent on and independent of time. A very simple comparison will, however, clear up the difficulty. Let us take the case of a tank or vessel to be filled with water by a small pipe. Let us for further suppose that 1 ft. in depth of water in this vessel will weigh 1 lb. Now we have here something analogous to the compound standard, the foot pound, before mentioned; and it is evident that the size of the pipe by which the water is run in will affect the question of time only—that is to say, that when the vessel is filled, for 1 ft. of its depth there will be 1 lb. of water in it, whether such water has been run in by a pipe of $\frac{1}{16}$ in. or 1 in. bore. In the first case the time would be 256 times as long as in the second, because the supply coming through a tube of $\frac{1}{16}$ in. is only $\frac{1}{256}$ of that fur-

nished by one of an inch bore. On consideration, therefore, it will be seen that the filling of the tank is also apparently at the same time dependent on, and independent of, the bore of the supply-pipe; and a little further consideration will show the analogy between the case of the water and that of the power. The comprehension of this general principle is necessary to the proper understanding of hoists of all kinds, and cannot fail to be of use to the reader in selecting apparatus the best suited to each case that may rise, namely: Whatever is gained in power must be lost in speed; and *vice versa.* Therefore a man must necessarily take twice as long to raise 2 tons weight to any height as to raise 1 ton to the same elevation; and no hoisting apparatus, however constructed, can in the least modify this law.

In selecting hoisting apparatus it is requisite to consider the weight to be lifted and the rate at which it must rise, and also the power of each man. Now the power of an ordinary laborer is about equal to the raising of one ton through one foot per minute. If, therefore, it is required to raise 1 ton at the rate of 1 ft. per minute—no matter what height—one man can do it. If at the rate of 2, 3, or 4 ft. per minute, 2, 3, or 4 men must be employed, and the hoisting apparatus chosen accordingly. If the rate at 1 ft. per minute remains the same, but the weight be increased to 2 or 3 tons, then 2 or 3 men must be engaged at gearing to suit the case. Simple and apparently obvious as these principles are, many cases occur where they are overlooked, to the great loss of those so forgetting the old saying *Ex nihilo nihil fit.* If these facts were more generally understood, we should hear less of So-and-so's Patent Quadruple Purchase Blocks for "gaining power and speed." Having thus far cleared the ground, we can proceed to examine the best contrivances hitherto introduced for hoisting purposes.

Of ordinary pulley-blocks it is not necessary to speak, as their specialties are generally known. We shall commence with differential pulleys. The principle of the differential pulley has been known from time immemorial, and, like other inventions hidden in obscurity, such as the compass, gunpowder, etc., its invention has been attributed to the Chinese. Be this as it may, its first application was by means of a windlass of differential diameter. On this windlass a rope was coiled partially on the larger, and partly on the smaller diameter. A part of the rope between the two diameters being allowed to hang down in a loop, a pulley was placed in such loop. If the windlass were turned in the direction necessary to cause the winding of the rope on to the larger diameter, it would at the same time unwind from the smaller; and if turned in the contrary direction, the rope would be wound on to the smaller as it was unwound from the larger. The pulley in the loop between the two diameters would therefore only rise or fall by half the difference between the length of rope taken up by one diameter and that given off by the other. Taking a case where the larger diameter was (say) 12 in., and the smaller 11 in., the respective circumferences would be 37.69 in. and 34.59 in. Speaking roughly, therefore, there would be a difference of 3 in. in one turn of the windlass. The movable pulley divides this difference by 2, so that for each turn the weight hung to the pulley would only rise or fall 1½ in. Supposing a winch handle at each end, having radii of 18 in., two men working continuously for eight hours per day could raise with this windlass no less a weight than 1 ton through 3 ft. per minute; and for a short time, even much more than this. Such contrivance is therefore so simple and so powerful that some urgent reason must have existed to limit its use, otherwise it would surely be more common than it is. Such a cause does exist in the excessive length of rope required; for instance, in the case just cited no less than 25 ft. of rope would be required to effect a lift of 1 ft. As might be expected, many attempts were made to overcome this inconvenience. These attempts all lay in one direction, namely to use a chain in place of a rope, and to make it act as an endless chain, by uniting the end from the larger diameter to that on the smaller. Pins were proposed to keep hold upon the chain, but were found useless; and all attempts failed till Mr. T. A. Weston introduced the now celebrated blocks which bear his name. In these blocks, the sheaves have recesses on the peripheries to fit the links of the chain, such recesses as the chain would make

if wrapped round a disc of clay or putty, and the chains are made with special care to insure the equality in size of the links. These blocks, as is well known, will not run down. They are therefore admirably suited for lifting castings and forgings on to machines or carts, and for lifting wrought or rough stones into any desired position, complete command over the load being attainable. They are not suited, however, for long lifts. That they supplied an urgent want may be gathered from their extensive and rapid adoption, there being at the present time perhaps sixty thousand sets in use. In these blocks an "improvement" known as Hardcastle's was made, to effect quick lowering by disengaging the two sheaves; but it has not proved a success in practice, this want of suceess arising chiefly from the fact that at the low lifts for which Weston's differential blocks are suited, the quick lowering does not compensate for the extra complication and trouble. In the blocks known as Eades's epicycloidal a different action is adopted, namely, a spur wheel running round inside an internally toothed wheel. The construction—which is difficult to convey in words—is such that while the spocket wheel revolves rapidly, the chain barrel goes very slowly; a very considerable increase of power can be obtained with these blocks, but of course only by a corresponding sacrifice of speed. There are also the several constructions of blocks introduced by Mr. Pickering. When we come to higher lifts than these several systems of blocks are suited for, the windlass and crab come into requisition. The ordinary constructions of windlasses and crabs are too well known to need any special description, and their principle of action is that already explained, the sacrifice of speed to gain power. To Mr. Weston we are indebted for the introduction of his friction coupling and brake, and his inclined "nip." These highly ingenious and scientific appliances have effected an advance in hoisting apparatus greater than any hitherto made. The extreme convenience and safety resulting from their use make them worthy of a fuller description than we can give in this article; we shall therefore reserve our remarks upon them for a future occasion. Amongst cranes we have every variety, from small manual power cranes to ponderous machines wrought by steam or hydraulic power. Hydraulic cranes have not as yet been applied to building purposes, though for the heavier kinds of construction they offer very great advantages. Steam cranes and derricks are largely employed, though not to the extent they might be. For the builder's purpose, however, the overhead traveller offers the greatest advantages, enabling every part of a building to be reached with ease, and ponderous masses of stone and iron to be placed in position with certainty, ease, and dispatch. The distinctive feature of the traveller consists, of course, in its possessing two rectilinear movements at right angles to each other. The one movement is effected by a main traveller moving on rails laid on an elevated scaffolding on each side of the site of the intended building. On the main traveller are laid rails on which the secondary traveller can move at right angles to the course of the main one. This secondary traveller carries the crab or hoist, and the means of hauling the small traveller backwards and forwards on the large one. The main traveller is provided with gear suited to traverse itself upon the line of rails first mentioned. The construction of the crab is one of the most important parts of the *tout ensemble* of a good traveller, as upon its action depends greatly the facility with which the masses lifted can be placed. The crab should be subject to the minimum amount of friction, must sustain its load at any point, and be capable of expeditious lowering under complete and instantaneous control. It is always a source of danger to have crabs in which the handles must be either used for lowering—in which case much time is lost—or in which they must revolve in a reverse direction, though not actually used; as in the latter case many accidents are likely to happen from their striking the men. It is far easier to lower a load—either small or great—by the controlling power of an efficient brake, than by any other means; in addition to this ease, an amount of safety and convenience otherwise unattainable is secured. The great difficulty hitherto has been to obtain a brake of ample power, instantaneous in action, requiring but a slight exertion on the part of the operator, and last, but not least, in a small compass. Such brakes are now, however, in very common use in

warehouses, docks, iron-works, etc., and builders will doubtless soon appreciate the advantages to be obtained by their adoption.

THE SCHINZ BLAST FURNACE.

From "Engineering."

In blast furnaces worked in the ordinary way with solid fuel, from 60 to 70 per cent. of the waste gases usually consist of nitrogen, and the quantity of this gas which is evolved from the mouth of the furnace may be taken as averaging from 5 to 6 tons per ton of iron made. Now, the heat carried off from the furnace by this nitrogen can only be utilized—and then only partially—by the employment of such arrangements of blast-heating stoves and boilers, heated by the waste gases, as will enable these latter to be ultimately discharged at a lower temperature than they leave the blast-furnace. If, for instance, the waste gases leave the blast-furnace at a temperature of 600°, and, after passing the boilers and blast-heating stoves, are ultimately discharged at a temperature of 400°, there will have been abstracted from them the heat due to the reduction of their temperature by 200°, this being of course in addition to the far greater amount of heat generated by the combustion of the carbonic oxide which the waste gases contain. In this way a portion of the heat carried off by the nitrogen from the blast-furnace may be utilized, but the greater part is eventually wasted. Let us suppose, for instance, a blast-furnace discharging 5½ tons of nitrogen per ton of iron made, and let this nitrogen be finally discharged at a temperature of 400° above the ordinary atmospheric temperature. In this case we have 5½ tons=12,320 lbs. of nitrogen heated 400°, and as the specific heat of nitrogen is .244, this corresponds to the carrying off of $12{,}320 \times 400 \times .244 = 1{,}202{,}432$ units of heat. It has been estimated by Mr. Siemens, that on an average each lb. of coke consumed in a blast-furnace generates 6,000 units of heat, and assuming this estimate to be correct, the heat carried off by the nitrogen in the above instance would be equal to that evolved from $\frac{1202432}{6000} = 200.405$ lbs., or about 1¾ cwt. of coke per ton of iron made.

In addition to the heat carried off by it, the nitrogen passed through a blast-furnace appears to do harm to a certain extent, by diluting the effective gases, and rendering the action of the carbonic oxide on the oxide of iron somewhat less energetic than it otherwise would be. To avoid these inconveniences and reduce the amount of nitrogen passed through any given furnace, Herr Charles Schinz, of Strasbourg, a metallurgist who has made the action of blast-furnaces his special study, has designed a method of working such furnaces partly with solid fuel in the ordinary way, and partly with carbonic oxide manufactured in separate generators, and forced in through independent tuyeres with the blast. As yet we are unaware that Herr Schinz's system has been tested on a practical scale; but we nevertheless think that it is at least worthy of the attention of those of our readers engaged in the iron manufacture, and under these circumstances we propose to describe it.

The theoretical principles on which Herr Schinz's system is founded may be very briefly stated. When a volume of carbonic acid is carried over coals, or over any substances containing carbon in a state of incandescence, half a volume of carbon will be absorbed, and two volumes of carbonic oxide will be formed. In the blast-furnace carbonic acid is invariably formed in the first instance, and when there is an excess of carbon present, this carbonic acid becomes transformed into a double volume of carbonic oxide. But in this case the resulting carbonic oxide is invariably mixed with that quantity of nitrogen which is due to the oxygen contained in the atmospheric air which has been used during the process of combustion, and it amounts to 3.77 volumes for each volume of oxygen. Therefore, two volumes of carbonic oxide + 3.77 volumes of nitrogen are formed in the first instance, and these, by the process of combustion, are converted into two volumes of carbonic acid + 7.54 volumes of nitrogen; whilst by Herr Schinz's process, which we shall hereafter describe, the gas

intended to be used for the purpose of combustion consists of only two volumes of carbonic oxide, which, through the process of combustion, produce two volumes of carbonic oxide + 3.77 volumes of nitrogen. In the application of Herr Schinz's system to blast furnaces, the carbonic oxide is, as we have said, injected simultaneously with the atmospheric air through separate tuyeres upon the incandescent fuel, so that the combustion of the carbonic oxide is effected in the very midst of the fuel, namely, in the hearth, where, owing to the presence of an excess of carbon, and through the resulting high temperature, the carbonic acid, which is one of the products of combustion, is again transformed into carbonic oxide. In this case, therefore, we obtain four volumes of carbonic oxide, and only 3.77 volumes of nitrogen; and Herr Schinz estimates that by the adoption of his system, the proportion of carbonic oxide in the waste gases may be increased nearly one-half, or about 48 or 49 per cent. of its present amount.

Before describing a furnace fitted up on Herr Schinz's system, we must say a few words respecting the manufacture of the carbonic oxide used as fuel. Herr Schinz considers that the most simple as well as the most economical method of generating carbonic acid on a large scale, is the decomposition by heat of the carbonate of lime (limestone), the residuary product of which in the shape of burnt or quick lime, finds nearly everywhere a ready market. The burning of the limestone is conducted in retorts or muffles, which are mounted in ovens of a peculiar construction, and the size of which is determined by the amount of carbonic acid given off by the limestone intended to be used, as well as by the quantity required in a given time. At a temperature of 1800° Fahr., the decomposition of the carbonate of lime requires about two hours. One cubic metre (35.316 cubic feet) of carbonic acid contains .5364 kilogrammes (1.18 lbs.) of carbon; and one kilogramme (2.2 lbs.) of carbonate of lime yields .44 cubic metre (15.54 cubic feet) of carbonic acid. Herr Schinz's object being to replace one-fourth of the carbon which serves the purpose of combustion in any furnace by the carbon contained in the carbonic acid derived from the decomposition of limestone, the quantity of carbonic acid required, for instance, for a furnace consuming 100 kilogrammes (220 lbs.) per hour will be = $\frac{100}{4}$ kilog. = 25 kilogrammes (55 lbs.); therefore, 25 kilogrammes = 46.6 cubic metres (1645.7 cubic feet) of carbonic acid must be produced per hour. Now if one kilogramme of carbonate of lime yields in two hours .44 cubic metre (15.54 cubic feet) of carbonic acid, it follows that for each cubic metre of carbonic acid, 4.545 kilogrammes (10 lbs.) of limestone must be under decomposition, and the capacity of the retorts or muffles must therefore be 211.8 kilogrammes (466 lbs.) or .163 cubic metres (5.75 cubic feet).

The carbonic acid gas thus produced is subsequently, in order to convert it into carbonic oxide, carried through a series of other retorts or muffles disposed in the same oven as those in which the limestone is burnt, and which are filled with small refuse pieces or particles of coke, or other combustible material in a state of incandescence. For the calculation of the requisite capacity of these retorts or muffles, the following experimental results will serve: .00474 cubic metres of carbonic acid per hour, requires at the temperature of 1800° Fahr., 1 square metre (10.764 square ft.) of contact surface for its conversion into carbonic oxide; therefore 1 cubic metre (35.316 cubic ft.) of carbonic acid per second requires to be brought in contact with 210 square metres (2260.44 square ft.) of surface presented by the pieces or particles of coke. The effect and determination of the contact surfaces of various kinds of fuel have been closely investigated by Herr Schinz; we cannot, however, follow his investigations here, but shall merely deal with his results. According to the above-mentioned example, where 46.60, or say 47, cubic metres (1,160 cubic ft.) of carbonic acid are supposed to require conversion into carbonic oxide, we have $\frac{47}{3600}$= .013055 cubic metre per second, whence by the equation .00474 : 1 : : .013055 : 2. 754, we should have to provide for a minimum contact surface in the retorts or muffles of 2.754 square metres (29.65 square ft.). Herr Schinz states that 1 cubic metre (35.316 cubic ft.) of fuel in pieces of the following dimensions, offer respectively the undermentioned contact surfaces, viz.: pieces of 1 centimetre (3.937 in.) diameter offer 314 square metres (3,379 square ft.,) those of 2 centimetres (7.87

in.) diameter offer 157 square metres ($1,689\frac{1}{2}$ square ft.,) and those of 3 centimetres (11.8 in.) diameter offer 104 square metres (1,119 square ft.). These figures show that, supposing the capacity of the retorts in which the carbonic acid is to be reduced, were to be made 30 times as large as they are absolutely required to be, in order to avoid the too frequent feeding, they would nevertheless be of a very moderate size. On extending these calculations to the requirements of a blast-furnace having a consumption of 900 kils. (1,980 lbs.) of carbon per hour, it will be found that 225 kilogrammes (495 lbs.) of this quantity would have to be supplied in the shape of carbonic oxide, of which consequently 420 cubic metres (14,833 cubic ft.) would have to be produced per hour. In this case the retorts or muffles required for decomposing the limestone must have a capacity of 1,4423 cubic metres (50.9 cubic ft.), and those intended for the reduction of the carbonic acid $30 \times .3 = 9$ cubic metres (318 cubic ft.), supposing the pieces of coke with which they are filled be small enough. This comparatively small size of the retorts or muffles, admits of their being heated to 1800° Fahr. by the waste gases evolved from the blast-furnace.

The carbonic oxide gas thus formed, is conveyed into a gasometer, dimensions of which must be adapted to the size of the works, and from this reservoir it is supplied to the blowing engine, and thereby forced into the blast-furnace. At the same time atmospheric air is supplied by means of another blowing engine, and this in such a manner that the proper relation between the volumes of gas and air is strictly maintained. The tuyeres employed by Herr Schinz are concentric; those placed internally serve for the conveyance of the gas. It is necessary during their progress to heat both the gas and the air to 750° Fahr., for the purpose of maintaining the temperature produced by the combustion at an elevation which shall be sufficient to convert the carbonic acid into carbonic oxide; but as the volume to be injected is much smaller than it would be under ordinary circumstances, it is possible to accomplish this by the blast-furnace gases.

Of the total amount of fuel expended in working a blast-furnace on his system, if the waste gases were not utilized, Herr Schinz estimates that one-half would be mixed with the other materials in the ordinary way, whilst one-fourth would be used in the retorts in converting the carbonic acid into carbonic oxide, and the remaining one-fourth in heating the retorts. This last quarter part can be saved by heating the retorts by the waste gases, while the fourth used in the retorts may be small coke, which would not be fit for use in the blast-furnace, and which is therefore of less value than that employed in the latter. In conclusion, we cannot do better than recommend those of our readers who are interested in blast-furnace improvements, to read Herr Schinz's treatise on the subject, an excellent French translation of which, by M. E. Fiévet, was published in September last.*

A NEW way of manufacturing lead pipes with a lining of tin has been devised by M. J. Grant, Jr. The first step is the formation of a muff coated with tin on the inside. This is made in a horizontal mould, which is made to revolve with great rapidity, and is provided with a hollow axle through which the metals are introduced. The metals are fused in a crucible furnished with a stopcock or a clack valve opening into the hollow axle of the mould. One crucible will suffice, the lead being placed at the bottom and the tin on the top, the two being separated by an iron grating; or the tin may be melted in a separate crucible, provided with a valve, and placed above that in which the lead is melted. The object is, of course, to run the lead into the mould first, and to allow the tin to follow while the former metal is still liquid. A rapid movement of rotation keeps the two metals from mixing, while a perfect junction is formed as they solidify. When sufficiently cooled, the muff is transferred to the press, and the pipes are squeezed out in the usual way. Tin-lined pipes ought to command an extensive use for carrying soft waters and beer, and, no doubt, would be employed if they could be produced at a small advance on the price of lead piping. The plan of manufacture described here deserves attention, although it seems open to doubt whether

* *Documents concernant le Haut-Fourneau pour la Fabrication de la fonte de fer.*. Traduits de l'Allemand avec approbation de l'Auteur, par E. Fievet.

the lining surface of tin would be perfectly continuous in the pipes. No doubt the adhesion of the two metals would be perfect.—*Mechanics' Magazine.*

SHELLAC VARNISH.—The solution of shellac in borax does not answer well as a varnish, on account of the quantity of borax dissolved. But the solution in ammonia serves a good purpose. Puscher publishes some suggestions for making varnishes of various colors with it. Most of the insoluble earthy colors may be mixed with it. Sulphate of lime, however, is said to decompose the solution. Extract of logwood easily dissolves in it, so likewise does aniline green. We have long employed it to make an indelible ink, which is especially useful for laboratory labels, a mixture of lamp-black with the shellac solution remaining quite unaffected by acid vapors. The colored solutions are, in fact, available for many decorative purposes. The plain solution is made by macerating 3 parts of white shellac in 1 part of strong ammonia diluted with 6 or 8 parts of water. This mixture must be frequently shaken for 12 hours, after which the solution may be completed by the application of a gentle heat.—*Mining and Scientific Press.*

METRIC WEIGHTS AND MEASURES.—A report on the subject of the construction of primary international standards of metric weights and measures has been made this summer to the Imperial Academy of Sciences at St. Petersburgh, by a commission of members of the Academy appointed to consider the matter. The commission, which consisted of MM. Struve, Wild, and Jacobi, regard as an accomplished fact that all civilized nations have tacitly agreed to recognize the French metric system as affording for the future the advantages of a universal system of weights and measures, and to adopt the standards deposited at the Palais des Archives at Paris as the primary units of this system ; but they observe that these are French standards, and all countries adopting the metric system are now compelled to apply to the French Government for permission to obtain copies. It is true that this permission is never withheld, but such copies are not compared directly with the standards of the Archives, but with duplicates at the Conservatoire Impérial des Arts et Métiers. The commission consider this course of proceeding unsatisfactory, and they propose that an international commission be nominated, composed of delegates from all civilized countries, for the construction and verification of primary international standards of measures of length, weight, and capacity, as the base upon which a universal system may be definitely established. They should also superintend the construction and verification of copies of these primary standards for the several countries.

THE CHANNEL PASSAGE.—A highly interesting discussion took place at the Society of Engineers, at which the position given to the bridge project of M. Boutet, at the previous meeting, as reported in last week's Journal, was fully maintained—that it is undoubtedly the best of the numerous projects for establishing a continuous railway across the Channel. It was clearly explained that there is to be seen at Paris, and has been seen by some present, a model 66 ft. long, made to scale, which bore ten times the weight which would be required to be borne by the Channel Bridge, constructed with less than 1 ton of metal, and that this rested on two abutments of rough timber which were incapable of sustaining any great strain; and it was forcibly urged that the English engineers should make themselves acquainted with the theory by which such extraordinary results have been obtained, and study it as a novelty, instead of judging it by existing examples of bridges, and condemning it without understanding it. There is no doubt that if it does not widely differ from every other bridge yet constructed, it is nothing; and, therefore, existing formulas are not applicable to it. It seemed to be generally admitted that the existing spans of bridges were no criterion of what could be done, and several engineers mentioned instances of long spans which, compared with our ordinary experience, are surprising. Amongst others, it was stated that Mr. Ordish had designed a bridge with a span of ½ mile, which Mr. Barlow checked and approved.—*Mining Journal.*

ON TUNGSTEN BESSEMER STEEL.

By CAPTAIN LEGUEN.

From "Comptes Kendus," through "Polyt. Journal."

I published some time ago a communication on my method of manufacturing tungsten Bessemer steel. This method consists in recarburizing Bessemer metal with a gray pig-iron, which originally was not of a superior quality, but was improved by the addition of tungsten or Wolfram metal. The steel thus produced was worked into rails, carriage springs, etc., and exhibited at the Paris Exposition of 1867.

I made lately the interesting experiment to alloy tungsten metal with spiegeleisen, instead of the ordinary gray pig-iron I had used before. The experiment was performed at the steel works of Terre-Noire (France,) whose Bessemer steel is used principally for rails. The pig-iron used at these works is manufactured from ores the greater part of which is imported from Mokta, near Bona, Algeria. The pig-iron is run from the blast-furnace directly into the Bessemer converter. The spiegeleisen is from St. Louis, and is remelted in a reverberatory furnace. My first operation was to combine a certain quantity of spiegeleisen with tungsten, by melting the iron in a cupola furnace, together with briquettes made from Wolfram ore, and reducing melters. I obtained thereby an alloy containing 9.21 per cent of tungsten metal.

A Bessemer charge was then made with 3,150 kilogrammes, or about 6000 lbs. of gray pig-iron taken directly from the blast-furnace. The process was conducted in the ordinary way, with the exception that the blowing was continued a little longer than usual, to obtain a very soft metal, and to see if the tungsten would be able to replace a part of the carbon in the steel without injuring the quality of the latter. A subsequent analysis showed that the steel made in this manner contained about half the amount of carbon then actually present in the steel fit for the manufacture of rails. The loss was ten per cent. The metal was recarburized with ten per cent. of the tungsten spiegeleisen mentioned above.

The metal produced contained .558 per cent. of tungsten. If no loss had occurred, the percentage would have been .837. The difference between these two numbers represents the amount of tungsten lost by oxidation in the reverberatory furnace and in the converter. When I made my previous experiments at the works at Imphy, this loss was more considerable, probably because the converter was turned up again for a short time after the addition of the recarburizer, which was not done at the Terre-Noire. It seems, therefore, probable that the loss of tungsten observed at the latter place originated exclusively in the reverberatory furnacc, and that no such loss took place in the converter. The rolling of the tungsten steel ingots did not exhibit any peculiar feature. They were rolled into rails for the French Eastern Railroad. The rails, when finished, were laid into the track of the Strasbourg depot in Paris. They were also tested by a breaking strain and by concussion, as well as by forging and hardening. The engineer who was intrusted with this testing, reported to me on the result as follows:

"The tungsten steel rails tested at the depot of the Eastern Railroad were highly flexible and tough. The steel worked perfectly well in being hammered and jumped. In turning it off, chips of remarkable strength were obtained. To investigate into its capacity of hardening, several bars, 25 millim. square, were forged and hardened at a cherry-red heat. The grain in the fracture of the metal was, before this operation, large, white, bright, and somewhat hooky; after being hardened, it was very fine, gray, and showed a peculiar lustre like velvet. Any steel made at Terre-Noire by the ordinary method, and hardening so well, would be too brittle to be used for rails. But the tungsten Bessemer steel combines the highest degree of toughness with an eminent capacity for hardening."

These remarks show that tungsten steel can be at the same time soft, strong, and capable of being hardened. It would, therefore, be very useful for such parts of machinery as require to be hardened in some places, without losing their natural softness in others. The administration of

the French Eastern Railroad proposes to have the tungsten steel rails laid down into the track in places where they are subjected to a heavy wear, so as to acquire an exact knowledge of the comparative durability of these rails.

A great objection to the use of tungsten steel for rails is its price, which is considerably higher than that of ordinary Bessemer steel. Indeed, if the tungsten alloy had to be made from the tungsten metal in trade, which is produced by reducing tungstic acid, and costs 1½ fr. per gram, the steel would be much too dear to be used for rails. My method of making this alloy is, however, much cheaper, and can be more simplified yet by melting the spiegeleisen and the Wolfram briquettes in a cupola instead of a reverberatory furnace, and by running the alloy directly from the cupola into the converter, so as to avoid re-melting, and the loss of tungsten metal caused thereby. This loss would then not be higher than about ⅓ of the total tungsten contained in the Wolfram ore, and the cost of the rails would be higher than that of ordinary Bessemer rails by only 3.8 francs per 100 kil., or 1.44 francs per metre (24 cents gold per year). This increase of cost is not considerable, and is by far outweighed by the great advantages to be expected from the superiority of the quality.

ON THE NEED OF FURTHER EXPERIMENTS ON THE STRENGTH OF MATERIALS.

By MR. C. J. LIGHT.

From "The Mechanics' Magazine."

At a meeting of the Society of Engineers, held on Monday, the 15th inst., Mr. F. W. Bryant, President, in the chair, the following paper was read: All sound engineering practice must necessarily be based upon experimental research into the strength of the materials employed, whether these experiments are purely scientific, and conducted with the accuracy and precision necessary to qualify them for supplying data on which to base formulæ for general use, or of a rough and ready character hardly to be recognized as experiments. For even the most ordinary proportions of parts must originally have been based upon trials—very often upon failures. It is with the former class only that the author now proposes to deal, and to point out how far, in some very important branches, it has hitherto failed in answering its proposed end.

Two essentials of useful experiment are, that all action whatever that could interfere with the sole development of the strains to be investigated should be carefully eliminated, and that the apparatus used should possess the means of measuring the results with the utmost possible accuracy and delicacy. These points are essential, because, where they are neglected, it becomes difficult to say what are even the limits of error, much less what corrections have to be applied to the results obtained. If this be thought too much of a truism, it will be sufficient to refer to the practice, once almost universal, of applying tensile strains by hydraulic pressure, and measuring the force by means of a gauge connected directly with the press itself, when the friction of the cup leathers introduced an element of uncertainty which entirely vitiated the accuracy of the results. When the object of the experiments is to establish formulæ, it is clearly necessary that, besides the above-named conditions of the apparatus, the samples operated upon should be prepared with the utmost care and precision; but the author would suggest that at the same time samples should be prepared from identically the same materials, but under as nearly as possible the ordinary conditions of manufacture, so that a comparison of the two classes might afford data for determining what proportion of the theoretical strength might reasonably be calculated on in practice.

Of late years great numbers of experiments have no doubt been made, especially upon the resistance of iron to tensile and transverse strains; but they have been generally for private purposes, and have not been allowed to become known. A noteworthy exception, however, is the valuable series of experiments in wrought-iron and steel carried out by Mr. Kirkaldy

for Messrs. Napier, and so fully published, with their permission. Upon the questions of tensile and transverse strains, therefore, it may be said that our information is fairly complete; but on the highly important subject of compressive strains it is admitted on all hands that reliable data are sadly needed. In a recent communication to the Institution of Civil Engineers, a French authority, M. Gaudard, remarks that "the case of a pillar pressed upon its bases is very imperfectly understood. We are almost reduced to the application of formulæ purely empirical, which aim rather at conforming to observed facts than at explaining them." Whether the formulæ we have to rely upon deserve even the modified description of "conforming to observed facts," may well be doubted after a very slight examination and comparison.

It is surely a matter of great surprise that the best series of experiments into the strength of columns and struts dates as far back as the year 1840, when Mr. Eaton Hodgkinson tested a considerable number of small columns of various diameters and proportions with the express object of determining practical formulæ. Since then nothing further has been done in this direction, and the results at which he arrived are still the admitted basis of calculation for columns and struts. It might, therefore, have been expected that these results were so clear and satisfactory as to render further investigation unnecessary, which, however, is very far from being the case. For example, the well-known formula for long hollow columns with both ends fixed, that is, according to Hodgkinson, columns whose length exceeds 30 diameters, is:

$$W = 44.34\,\frac{D^{3.55} - d^{3.55}}{L^{1.7}}$$

Where W = breaking weight in tons.
D = external diameter in inches.
d = internal diameter in inches.
L = length in feet.

On seeing so peculiar an index or exponent as 3.55 in a professedly empirical formula, it is natural for the student to suppose that the experiments rendered results at least very closely approximating to the index finally adopted. What, therefore, must be his surprise to find that in fact the indices obtained from the various experiments ranged from 3.922 to 3.412? (see the foot note page 333 of Mr. Hodgkinson's work). That is, if the external diameter be 12 in., the factor to be employed might range from $12^{3.922}$=17082, according to one experiment; to $12^{3.412}$= 4810, according to another. The same remark applies to the factor $L^{1.7}$, as it appears that the index varied from 1.914 to 1.424.

In the sixth edition (1867) of Barlow on the Strength of Materials, edited by Mr. Humber, a short article on cast-iron columns has been inserted, which is an almost verbatim extract from Hodgkinson's work above referred to, and in which his formulæ are adopted as the best yet known, with a modification suggested by Mr. Hodgkinson, viz., taking the index of the diameter as 3.6 both for columns with fixed and with rounded ends. It is somewhat anomalous that, while adopting this modification, the effect of which is very considerable even in columns of moderate diameter, what may be almost called the affectation of extreme accuracy is retained in the constants of 44.3 for hollow and 44.16 for solid columns, where it is obvious that the decimal part exercises an influence upon the result perfectly insignificant as compared with that of the slightest change in the indices.

Another serious cause of uncertainty arises from the admittedly different kind of resistance offered by very long and very short columns, the one being principally a resistance to crushing and the other to flexure. Mr. Hodgkinson came to the conclusion that his formula for long columns could be adapted to short columns, at least for certain classes of iron, by means of the following expression:

Breaking weight of short column = W

$$= \frac{W \times C}{W + \frac{3}{4} C}$$

where C is the crushing force in lbs. belonging to the material employed $\times$ the sectional area of the column. As, however, C will in all ordinary cases be very large in proportion to W, the expression practically resolves itself into w=$\frac{4}{3}$ W.

Now it is obvious that this is a most unsatisfactory solution, for it cannot be supposed that there is any point at which a sudden change of so considerable an extent takes place. Or, to bring the question to the test of an example, let it be supposed that the column whose break-

ing strength is sought is 30 ft. long, 12 in. external, and 12 in. internal diameter, is it to be classed as a long or a short column? In the former case, its ultimate strength would be, according to Hodgkinson's formula, 442 tons, in the latter 589. Nor, if it be admitted that there are two such distinct classes as long and short columns, is there any certainty as to the proportion at which the change occurs, other authorities placing it as low as 5 diameters in the case of cast-iron.

Leaving for a time the consideration of Hodgkinson's formula, the next that claims attention is that given by Professor Rankine:

$$W = \frac{Sf}{1 + \frac{l^2}{c\,r^4}}$$

Where S = sectional area of a column, l = its length in inches, r the least radius of gyration of its cross section, f and c two coefficients depending upon the material, and appearing to have relation to its powers of resistance to compression and tension. It will be seen that no comparison can be made between this formula and Hodgkinson's, but it is evident that Rankine's bears a more purely theoretical character, and that it involves the fourth power of D, in which respect it agrees with that originally laid down by Euler, which Hodgkinson thought could only be reconciled with practical results by modifying the index as before noticed.

Besides these formulæ, there is also one quoted by Molesworth, though from what authority it was derived the author has been unable to ascertain. It is given on the 19th page of his Pocket-book, and called an "Approximate Rule for the Strength of Iron Struts," without any limitation as to the proportions between their length and diameter. For the case of hollow columns of cast-iron this rule gives:

$$W = S\,36 \div 1 + \frac{l^2}{400\,D^2}$$

$$\text{or} = S\,\frac{36}{1 + \frac{l^2}{400\,D^2}}$$

Rankin's formula adapted to a similar case would be

$$W = S\,\frac{80{,}000}{1 + \frac{8\,l^2}{3{,}200\,D^2}} \qquad = S\,\frac{80{,}000}{1 + \frac{l^2}{400\,D^2}}$$

so that the forms are identical, while the difference of the coefficient is, in this case, but trifling, as Rankine's formula gives the value of W in lbs., and 80,000 lbs. = 35.715 tons. When, however, the material of the column is wrought-iron, the similarity of form continues; but the coefficients differ so greatly as to cause great discrepancy between the results—a discrepancy varying with the relations between the length and diameter. The same remarks apply to the formulæ given for columns of a hollow square and a cruciform section.

To assimilate the formulæ for wrought-iron to those of Rankine, they must be altered thus:

For cruciform, section, $16 \div 1 + \frac{l^2}{1{,}500\,D^2}$

For hollow square section, $16 \div 1 + \frac{l^2}{3{,}000\,D^2}$

For hollow cylinder section, $16 \div 1 + \frac{l^2}{4{,}500\,D^2}$

In order to show how great is the variance between the different formulæ, and therefore how uncertain any calculations of the strength of columns must be, it will now be desirable to give the results in a few practical instances. First, let the case be that of a cast-iron column 30 ft. long, 12 in. external and 10 in. internal diameter, with the ends flat. Hodgkinson's formula will give its breaking weight, if it be considered as a long column:

	TONS.
With index 3.55	442
With index 3.6 (said to be sufficiently near for practice)	505
If taken as *short* column	589
Or the same with index 3.6	631
According to Rankine's formula, taken as long column	380
According to the formula on page 19 of Molesworth	383

Which of these results, the extremes being as 5 to 3 very nearly, is to be taken as the true breaking weight of the column?

Again, take the case of a column, also of cast-iron, 30 ft. long, 24 in. external and 20 in. internal diameter, with the ends rounded, or, what is the same in effect, jointed. Hodgkinson's formula gives, with what he considers the true index for D, viz., 3.76:

	TONS.
Breaking weight	3,080
With the index 3.6 ("quite near enough for practice," let it be remembered!)	1,797
Or, if it be taken as a *short* column, which	

	TONS.
at the proportion of 15 diameters to the length, we have a right to do..........	4,107
Taken as a long column, by Rankine's formula..................................	1,519
By formula page 19 Molesworth..........	955

In this case the extreme values obtained for W are to one another as 43 to 10, very nearly. How is it possible to arrive at any idea of the real strength of such column, which is yet one of very probable dimensions. If, however, wrought-iron be the material employed, the discrepancies become still more startling. Assuming the case of a similar column to the one first instanced, only in wrought-iron:

	TONS.
Hodgkinson would give....................	771
Rankine..................................	463
Molesworth...............................	170

The first result is based on the statement that the relative strengths in long columns of wrought and cast-iron are as 1745 to 1000—an hypothesis which must be entirely erroneous, for the ultimate crushing strength due to the area of this column, without any consideration of its liability to flexure, is only 586 tons (calculating at 38,000lbs. on the sq. in.).

The uncertain results of Mr. Hodgkinson's experiments must, there is no doubt, be chiefly attributed to the small size of the columns operated upon, and not to any want of skill or care on the part of the operator. The largest solid column tested was only 5 ft. long and 2 in. diameter, and in hollow columns the greatest length did not exceed 7 ft. 6 in. with a diameter of 3½ in. The more powerful means of testing now at the command of engineers would allow of experiments being made upon a much larger scale, and, it is reasonable to anticipate, with far more uniform results.

Before leaving this part of the subject it will be well to notice a remark of Mr. Hodgkinson ("Phil. Trans," 1840) respecting cases of imperfect casting in hollow columns, where the metal on one side was considerably thinner than on the other. He says: "It is gratifying to find that a matter which would seem to destroy all confidence in a pillar does not produce a great reduction in the strength." This apparent anomaly he explains by supposing that by some natural law the thinner side always takes up the compressive strain, and the thicker the tensile, and the instances that accidentally occurred among his experiments, certainly confirmed this supposition. This will be an important point for future observation.

In reference to wooden pillars or columns, it will be sufficient to remark that the best established formulæ give results which differ from each other in a similar manner to those for iron, though not to quite the same degree.

Enough has probably now been said to show how impossible it is, with our present information, to determine within anything but the roughest approximation what load any given column ought to bear before breaking. It is true that even if strict accuracy were attainable in this respect, there would yet remain the variations of material and workmanship to be allowed for, besides the important question of the factor of safety that should be adopted. But the author would urge that we ought not to be content until a theoretical basis has been established as certain and rational as that upon which calculations of transverse strains are now based.

Another class of experiments, much more readily to be made, and of a much simpler character, would yet be of great practical utility. Their object would be to determine the resistance to tranverse and compressive strains of wrought-iron L and T bars of various sections, and to deduce therefrom practical rules. It is very probable that ample materials already exist in private hands for compiling such information, and, if not, the necessary experiments could be easily and cheaply made. This is not a case requiring extreme accuracy, especially as it would be the actual full-size bars that would be operated upon; but every engineer ought to have the means of determining at a glance what load any given bar will probably bear. Such tables would be the means of saving many a ton of metal in roofs and flooring, etc., and would afford the designer an assurance of the efficiency of his structure, which he cannot at present be said to have.

The next series of experiments to the need of which the author desires to call the attention of the Society would require very great care and skill, both in arranging and in carrying out. They refer to the true proportioning of the eyes of links. It is now many years since attention was first directed to the necessity for provid-

ing, not only a sufficient shearing area in the bolts or pins securing links, tie rods, etc., but also a sufficient bearing area of the link or tie itself upon the bolt—a point which appears to have been overlooked, at least in civil engineering, until the rapidly extending use of iron roofs, and the desire to reduce every part to the slightest possible form, brought it into prominence. And even now there is great difference of opinion as to the extent of such bearing area, some authorities contending that the crushing strain so induced ought not to be allowed to exceed (for wrought-iron) 5 tons to an inch, while others would extend the limit to 7 or 8 tons. The correct proportions for the eyes of links whose thickness is small in proportion to their breadth, as in those of bridges, still present a vexed question; and it is not easy to determine how far they are affected by the unavoidable irregularities of manufacture.

Experiments appear to show that the proportions at present adopted in the best practice, though greatly modified from those at first used, are even yet insufficient to secure the fracture of the link through the body in preference to the eye. The author submits that it would be highly desirable to arrange and carry out a series of experiments on links of graduated cross sections, from the thin link, as employed in the lower members of bridge girders, to one of a square section, with a view to determine the proper proportions for the eyes under these varying conditions. It is, however, quite probable that a large amount of information already exists suitable for such determination if it could only be brought together under such conditions as to permit of a fair comparison of results.

Upon the strength of timber as a material of construction there have been made so great a number of experiments that it may be doubted whether fresh ones would add much to our knowledge of the subject. It may be remarked, however, that the greater part of these, also, are open to the objection before referred to, of having been made upon exceedingly small pieces. It is also true that with timber so very much depends upon the age, the growth, and the place of growth of the tree, that it can never be expected that calculations for this material can be brought within the same limits of accuracy which may be fairly looked for in the case of iron.

Further experiments are probably desirable on the strength of combinations of timber and iron, such as trussed beams, keeping in view the consideration that the timber must necessarily yield to a considerable extent before any appreciable strain is brought upon the iron tie. This objection is of much greater force in the case of the flitch girder, in which the timber ought only to be looked upon as giving lateral stiffness to the iron plate.

In reference to the important question of the strengths of stone, brick, cement, and artificial stone, there is still room for a well-arranged series of experiments, especially if made upon much larger samples than those which have hitherto been operated upon. Another interesting subject for fuller experiment is that of glass, as laid in sashes both of wood and iron. In the latter case, observations should be made under varying temperatures. The object of this paper has been, not so much to call the attention of engineers to a want which the author is well aware is already known and admitted, as to elicit from all who take an interest in the subject such information as they can contribute to the common fund, and such suggestions as may lead to a practicable remedy for a state of things which cannot be considered creditable to the present position of engineering science.

Some interesting experiments have taken place at Perm, Russia, with a new 20-in. gun, cast in the foundry of that town. The trials made with this gun, under the direction of Major-General Pestitch, commandant of the Cronstadt artillery, are described in the official reports as having been very successful, and more satisfactory in their results than had been the case with American guns of the same calibre. The gun was fired 314 times; the projectile weighs 10 cwt., and the charge of powder required for each shot was 130 lbs. The weight of the gun is about 50 tons, the recoil 7 ft., the initial velocity of the projectile 1,120 ft. per second, and the percussion force, at a distance of 50 ft., about 10,000 tons. The official papers say this is "the most powerful gun in Europe."

Thomson's Road Steamers in Paris.—Within the last few days one of Mr. R. W. Thomson's road steamers, with india-rubber tyres, has been running through the streets of Paris, dragging behind it a heavy Versailles omnibus, with 50 passengers. On the report of the French Government engineers, leave has been granted to the road steamer to ply over two routes, several miles in length, and including some busy parts of Paris. The engineers report it more handy and manageable than horses, and in no way dangerous to the public. The huge india-rubber tyres save the machinery from jolting and the road from ruts. The speed is that of a fast omnibus; it went up the paved street beside the Trocadero, of which the gradients are 1 in 11, and even 1 in 9, without the least difficulty, and came down again without any brake. In a wet grass field it was curious to observe how little the wheels sank into the saturated soil; in fact, it obliterated, on retracing its circle, the deep ruts of the omnibus wheels. This circumstance has drawn the attention of artillery officers present at the experiment, suggesting to them an inquiry whether the system might not be advantageously applied to military transport in campaigning.—*Engineering.*

The Detroit River Tunnel.—The experimental borings for the projected tunnel under the river at this point have now virtually been concluded. The earth was found to be more and more favorable at each successive trial. Occasionally soft "streaks" were found near the surface, but a few feet down a hard tenacious formation of blue clay was invariably reached, which presents a very uniform appearance. The greatest depth of water is found about 1200 ft. from the shore, where it is about 48 ft., whence it gradually shoals to a depth of about 25 ft., upon this side. The depth above named (48 ft.) may be considered the maximum, except so far as it is varied by holes. The depth of the borings is 98 ft. from the surface. The soundings of the river vary somewhat from those which have been made under the auspices of Government, but this is very natural in view of the difficulty of taking accurate soundings with the lead in a current of three and a half miles an hour. The figures now arrived at are strictly accurate, being taken with an iron rod confined in a tube, which tube is stayed in such a manner as to prevent swaying even in the remotest degree.

Oscillation of Railway Trains.—Sir Charles Fox states his opinion that the oscillation of railway trains, more especially at high velocities, producing what is ordinarily called "gauge concussion," is caused in a very great measure by the use of wheels the tyres of which are portions of cones instead of cylinders. It is well known to engineers that the tyres of railway wheels are generally coned to an intonation of 1 in 20. It is considered that these were first introduced by George Stephenson, in the expectation of facilitating the passage of vehicles round curves by their adapting themselves, through their various diameters, to the different lengths of the two rails on which they were running. This, however, is not the case in practice. No advantage is found to arise in the use of conical wheels in passing round curves, and as much evil results therefrom on straight lines, Sir Charles has constructed upward of 250 miles of railway abroad, in the rolling stock of which he has departed from the usual form of wheel, and has used only cylindrical ones, and he has been gratified with the satisfactory reports of the steadiness of trains supplied with them.—*Engineering and Mining Journal.*

British Mining Statistics.—Last year 296,660 persons were employed in coal mining in England and Wales, and 59,160 in Scotland. The quantity of coal raised in Great Britain was 104,566,959 tons. There were 860 separate fatal accidents, and 1,011 lives lost, the proportion of persons employed for separate fatal accidents being 403, and 343 employed to every life lost. Every 103,429 tons of coal raised appears to have cost a life. These operations were carried on in 3,262 collieries. There were also 69 lives lost in iron-stone mines.

A Finland vessel has conveyed to St. Petersburg two enormous blocks of stone from the banks of Lake Lodoga, each weighing 72,000 lbs, to be used for the pedestal of the statue of Catherine II.

THE CONTRACTION OR SHRINKING OF TIMBER.

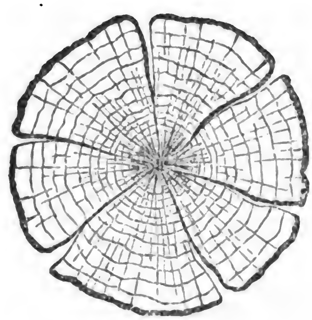
From "The Builder."

In a lecture on Applied Mechanics delivered by Mr. John Anderson, C. E., at the Society of Arts, some information was given on the contraction of timber, which calls for transference to our paper:—

Notwithstanding the extent to which timber is used in the mechanical arts, it is singular that the mechanical law by which the contraction or shrinking of wood is governed is too much disregarded in practical operations. I am not aware of any book that explains the subject fully, and have met with only one individual who has thoroughly studied it as a philosophical question and reduced it into the unerring every-day practice of his own works. The wretched state of the floors, doors, and shutters in many of the London houses, too plainly gives ample and complete evidence of our persistent disobedience of the law, and the only hopeful consolation is that as we do not go unpunished, the penalty inflicted may in time lead to improvement.

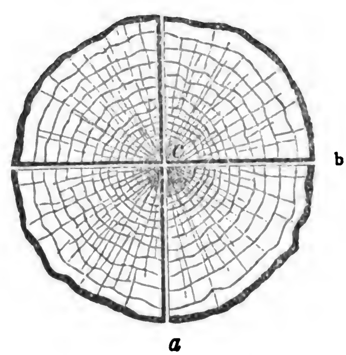
An examination of the end section of any exogenous tree, such as the beech or oak, will show the general arrangement of its structure. It consists of a mass of longitudinal fibrous tubes arranged in irregular circles that are bound together by means of radical strings or shoots, which have been variously named. These are the "silver grains" of the carpenter, or the medullary rays of the botanist, and are in reality the same as end wood, and have to be considered as such, just as much so as the longitudinal woody fibre, in order to understand its action. From this it will be seen that the lateral contraction or collapsing of the longitudinal porous or tubular part of the structure cannot take place without first crushing the medullary rays; hence the effect of the shrinking finds relief by splitting in another direction, namely, in radial lines from the centre, parallel with the medullary rays, thereby enabling the tree to maintain its full diameter, as shown in Fig. 1. If the entire mass of tubular fibre composing the tree were to contract bodily, then the medullary rays would of necessity have to be crushed in the radial direction to enable it to take place, and the timber would thus be as much injured in proportion as would be the case in crushing the wood in the longitudinal direction. If such an oak or beech tree

Fig. 1.



is cut into four quarters, by passing the saw twice through the centre at right angles, before the contracting and splitting have commenced, the lines *a*, *c*, and *c*, *b*, in Fig. 2 would be of the same length,

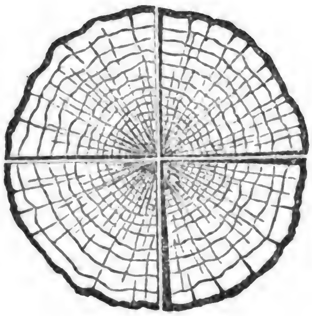
Fig. 2.



and at right angles to each other, or, in the tecnical language of the workshop, they would be square; but, after being stored in a dry place, say for a year, it would then be seen that a great change had taken place both in the form and in some of the dimensions; the lines *c*, *a*, and *c*, *b*, would be the same length as before, but it would have contracted from *a* to *b* very considerably, and the two lines *c*, *a*, and *c*, *b*, would not be at right angles to each other, by the portion here shown in black in Fig 3. The medullary rays are thus brought closer by the collapsing of the vertical fibre. But, supposing that 6 parallel saw-cuts are passed through the tree so as to form it into seven planks, as

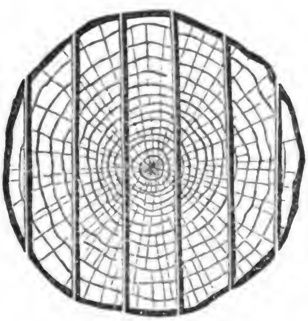
shown in Fig. 4, let us see what would be the behavior of the several planks. Take the centre plank first. After due seasoning and contracting, it would then be

Fig. 3.



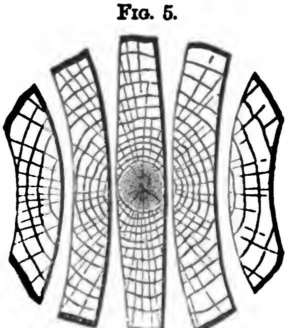
found that the middle of the board would still retain the original thickness, from the resistance of the medullary rays, while it would be gradually reduced in thickness

Fig. 4.



towards the edges for want of support, and the entire breadth of the plank would be the same as it was at first, for the foregoing reasons, and as shown in Fig. 5.

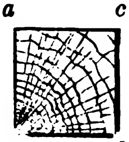
Fig. 5.



Then, taking the planks at each side of the centre, by the same law their change and behavior would be quite different; they would still retain their original thickness at the centre, but would be a little reduced on each edge throughout, but the side next to the heart of the tree would be pulled round or partly cylindrical, while the outside would be the reverse, or hollow, and the plank would be considerably narrower throughout its entire length, more especially on the face of the hollow side, all due to the want of support. Selecting the next two planks, they would be found to have lost none of their thickness at the centre, and very little of their thickness at the edges, but very much of their breadth as planks, and would be curved round on the heart side and made hollow on the outside. Supposing some of these planks to be cut up into squares when in the green state, the shape that these squares would assume, after a period of seasoning, would entirely depend on the part of the tree to which they belonged; the greatest alteration would be parallel with the medullary rays. Thus, if the square was near the outside, the effect would be as shown in Fig. 6, namely, to contract in the direction from *a* to *b*, and after a year or two it would be as seen in Fig. 7, the distance between *c* and *a*

Fig. 6.

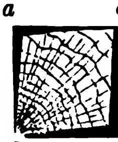
a *c*



d *b*

Fig. 7.

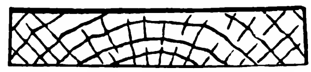
a *c*



d *b*

being nearly the same as they were before, but the other two are brought by the amount of their contraction closer together. By understanding this natural law, it is comparatively easy to know the future behavior of a board or plank by carefully examining the end wood, in order to ascertain the part of the log from which it has been cut, as the angle of the ring growths and the medullary rays will show thus, as in Fig. 8. If a plank has this ap-

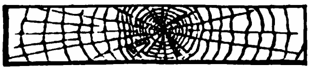
Fig. 8.



pearance it will evidently show to have been cut from the outside, and for many years it will gradually shrink all to the breadth, while the next plank, shown in Fig. 9, clearly points close to the centre

or heart of the tree, where it will not shrink to the breadth, but to a varying thickness, with the full dimensions in the middle, but tapering to the edges, and the planks on the right and left will give a mean, but with the centre sides curved round, and the outside still more hollow.

Fig. 9.



The foregoing remarks apply more especially to the stronger exogenous woods, such as beech, oak, and the stronger home firs. The softer woods, such as yellow pine, are governed by the same law; but in virtue of their softness another law comes into force, which to some degree affects their behavior, as the contracting power of the tubular wood has sufficient strength to crush the softer medullary rays to some extent, and hence the primary law is so far modified. But even with the softer woods, such as are commonly used in the construction of houses, if the law is carefully obeyed, the greater part of the shrinking, which we are all too familiar with, would be obviated, as the following anecdote will serve to show:—It was resolved to build four houses, all of the best class, but one of the four to be pre-eminently good, as the future residence of the proprietor. The timber was purchased for the entire lot, and the best portions were selected for house No. 1, but by one who did not know the law, and to make certain of success this portion of the wood had an extra 12 months' seasoning after it was cut up. The remainder of the wood was then handed over to a contractor for the other three houses, who had an intelligent young foreman, who knew the structure of wood, as well as how to obey the law, and who, therefore, had the wood for the three houses cut up in accordance therewith. The fourth house was built the following year by another man; but long before 10 years had passed, and to the great surprise and annoyance of the proprietor, it was found that his extra good house, No. 1, had gone in the usual manner, while the other 3 houses were without a shrinkage from top to bottom. As Solomon says, "Wisdom is profitable to direct."

A similar want of correct knowledge of the natural figure and properties of the structure of wood, such as the oak, is constantly shown by the imperfect painting to resemble that wood, as exhibited on the doors and shutters of many of the houses of this metropolis. If we cannot afford to have genuine wainscot doors, as in France, but yet desire to have an imitation, it would surely be worth the trouble to have a block cut from the quarter of an oak tree, and to have each of its six sides planed and polished, in order to make plain their several features. The house-painter would then see what nature really is, and thus save us from the ridicule of other nations, when we mix up "silver grains" and all the other natural features upon one side of a board or panel.

At the ironworks of Aulnoye, in Belgium, the slag is utilized by casting it into slabs for paving, garden rollers, and other things. For the former purpose, moulds are excavated in the ground around the furnaces, of sufficient extent to receive all the slag running from them, and trenches are cut to carry the liquid slag. The only precaution to be taken, we are told, is to cause the slag to run under the vitreous layer, which solidifies at the beginning of the running, and to keep the moulds warm, so that the slabs may not solidify too rapidly. For this purpose it is often necessary to cover up the trenches and moulds with cinders and small coal. The cooling should indeed, be made to occupy several days; and, in that case, there will be found under the vitreous crust a compact homogeneous slab, in appearance very much resembling natural porphyry. The masses are often divided by fissures, but the pieces can be dressed and trimmed into blocks for paving. To obtain sound rollers, it is necessary to take especial care in the cooling and solidifying. It is hardly necessary to add that the slags employed for these purposes must be solid and lasting, and not at all brittle.—*Mechanics' Magazine.*

To prevent accidents to workmen in wells, a safety cradle, consisting of a framework of wood with a rope matting or basket, to be fixed a little under water, is proposed. This seems an excellent suggestion, and well calculated to save many lives.

WHITWORTH METAL.

From "The Railway Times."

It is well known to mechanics that Mr. Whitworth has been long engaged in testing a new process of making and casting iron and steel, which he has invented with the view of getting rid of all those accidents which arise from the air bubbles found more or less in all iron castings, and not removable by any amount of hammering. Mr. Whitworth has now perfected a mode of casting metal which renders it so homogeneous that it resists any given forces which can be brought to bear upon it. The following notice which recently appeared in the London "Times," gives an interesting account of the application of the Whitworth metal to ordnance. The notice is written by an officer of the Royal Artillery, thoroughly acquainted with the subject:

"Mr. Whitworth has long been known as a mechanician of the highest order To him is due the accuracy with which machinery may now be made to turn out work almost perfect in its beauty and precision of dimensions. When once the transference of circular into direct or eccentric motion, and the converse, was achieved, it was easy to devise a thousand means of carrying the discovery into practice, and, theoretically, of producing any, even the most delicate forms. But the main difficulty had still to be surmounted. The machines themselves were imperfect in dimensions. There was no such thing as an exact plane in existence, much less an exact sphere or cylinder or cone. Every part of every machine was really rough and uneven in surface, however precise it might appear to the naked eye, and it is clear that wheels of imperfect roundness, turned by equally imperfect shafts, working in imperfect beds, could never turn out perfect productions. The defects continued to reproduce themselves, for the parts of new machines were made by the old ones. A beginning had to be made somewhere. Mr. Whitworth set to work to make plane surfaces of mathematical accuracy. First manufacturing three flat pieces of hard metal as exact as was possible by the ordinary means, he then rubbed two of their surfaces together till there remained no perceptible friction. He then took the third and worked it on to the two others, continuing the process till the three were so equal that, if any two of them were laid one upon the other, they touched nowhere, the upper one floating on an extremely thin film of air between them, without friction. If the edge of the upper one was pressed on the lower surface and pushed along it, followed by the body itself, there was no air between, and the two adhered together, held fast by the pressure of the atmosphere above and below. Here was the germ from which sprang exact spheres, cylinders and wheels, the parts of machines which could be relied upon. Henceforward there was no limit to the preciseness of the productions, except the wearing of tools or of the machinery itself. But a finer test of the work was required than any then in existence; so Mr. Whitworth designed a measuring instrument, capable of marking faults for correction even if they did not exceed the millionth of an inch. So the work produced and the parts of the machines could be rigorously tried, and many a new flight could be taken in the region of mechanics.

"When the demand came for small arms and cannon of longer range and closer shooting, Mr. Whitworth carried out a series of experiments for the Government, laid down what he considered to be the laws governing the rifling of barrels and the shape of projectiles, and produced a rifle which attained results hitherto unknown. He proceeded to apply the same principles to artillery, and competed with Armstrong for the position of first artillerist in the world. But his rival had already, not designed, but built a large number of guns fulfilling in their construction the demands of practical soldiers, as well as those of scientific artillerists. The ground was already occupied, and when it was found that neither inventor could claim any decided superiority over his antagonist, the strong practical objection to complication of guns and ammunition, by the adoption of two complete systems side by side, was, very properly, allowed to weigh against Mr. Whitworth. If the public service be the first consideration, many an ingenious inventor may find that

there is no room for his works, though he may well deserve a handsome acknowledgment in one shape or another.

"Since the days of the Armstrong and Whitworth Committee, Mr. Whitworth has never dropped the subject of artillery. It was not enough for him to be acknowledged as the first machinist in England, he must also be accepted as in the front rank of artillerists—a desire which he shares in common with many others. Such an end is only to be attained by the manufacture of reliable heavy rifled guns, such as 300, 400, and 500 pounders, or pieces of even higher calibre, and Mr. Whitworth was long unsuccessful in producing anything higher than a 7-in. gun. His system of gunnery is acknowledged by himself to be very severe upon the piece from which his long projectiles are fired, and we have more than once heard from his own lips that he sought in vain for a material which could be relied upon, and produced in sufficient quantities. He adopted a mild steel as the metal theoretically most adapted to withstand both strain and wear, but he found, as all makers of steel guns have found, that the greatest care was unavailing to produce trustworthy steel tubes in large quantities and of large sizes. Many a fair-seeming piece of a gun would stand steady strains carefully, but crack when the sudden shock of fired gunpowder occurred within it. So much material could not be wasted without increasing the cost of that which was sound, nor could guns be produced rapidly or in large quantities. The English Government would hardly accept 9-in. guns costing £3,200 each, except for purposes of experiment, when pieces of equal calibre could be bought from Armstrong for considerably less than half the price, or manufactured in the Royal Arsenal, on Fraser's still cheaper system, for little over a fourth. Two such guns were purchased before the late Conservative Government came into office, and their shooting was, what Whitworth shooting has always been, extremely good. The experiments with them seem to hang fire, chiefly, we believe, on account of some lack of harmony between Mr. Whitworth's idea of fair experiments and those of the Ordnance Department in the War Office.

"The subject would have been of little importance, but for a most interesting and valuable attempt of Mr. Whitworth to solve the one great problem of artillerists, by producing guns at once strong, cheap, and capable of being manufactured in large quantities. In spite of all researches, the reasons for the peculiar qualities of steel are still doubtful, but the most important and undesirable quality, that which breaks the hearts of gunners, is the uncertainty of the metal. Of two tubes manufactured at the same place, about the same time, by the same workman, one may stand 1,000 rounds, and the other burst destructively at the first or fiftieth round, sometimes without the slightest warning. One reason given is that bubbles of gas formed in the molten steel before it is set are retained by the thickening fluid, and perpetuated as flaws in the ingot, no matter how severe a hammering it may have had. Mr. Whitworth claims to have succeeded in getting rid of these gas or air bubbles entirely, by the application of immense pressure to the mass of molten metal while cooling. He has four qualities of this steel, or "Whitworth Metal," as he calls it. They are known as yellow (having most carbon,) blue, brown, and red, the red being the most ductile. He has tried many experiments on a small scale, and considers himself to be justified in declaring that he will now be able to make heavy guns perfectly trustworthy at a price of about £120 a ton, or one-fifth higher than Sir W. Armstrong's present prices, and rather more than half his own old ones. A 9-in. gun would cost £1,800, but then its projectiles would be heavier, and its power greater than its rival of the service pattern. Mr. Whitworth is pre-eminently an advocate of small bores in guns as well as rifles, being ready to sacrifice many practical advantages for good shooting. He now asserts that he throws to the winds all fear of his guns bursting. Instead of seeking for powder of less severity, his only wish is to find means of igniting it more rapidly, and he is making preparations for the construction of 27-ton guns, or even pieces weighing over 43 tons.

"It may be that Mr. Whitworth has achieved a task which would certainly lead to the adoption of his metal for the inner tubes, at least, of all guns, whatever might be their system of shooting; but the experience of all practical artillerists denies them permission to accept experiments on a small scale, as applicable to

heavy guns, in which the force of the explosion is vastly multiplied, possibly even altered in its mode of action. The Government possesses two heavy Whitworth guns, but they are not made of the new metal, except in very small proportion applied to the exterior of the piece. They may be very useful to test ammunition, system of rifling, and so on, but their lasting qualities will prove nothing as to strength of the new metal for guns, because they are made of the old metal. We understand that the superintendent of the gun factories applied to Mr. Whitworth for inner barrels, but was answered that the whole system or nothing must be taken. This seems a little obstructive; but here is a man of reputation asserting that he has the power of producing metal of extraordinary strength, and that he has actually commenced to make two 11-in. guns calculated to fire shells of 960 lbs. If he will not allow his material to be tried as a part of the Government ordnance, we cannot but think that it would be worth while to order one gun from him, embodying his newest ideas, and test it in everyway without competition, for it seems that in this way alone can the authorities arrive at truth regarding the strength of the Whitworth metal as applied to heavy guns. It should be distinctly understood that Mr. Whitworth's system of charges and projectiles is acknowledged by him to be extremely dangerous to the endurance of the pieces of ordnance themselves, and must be rejected unless he can find material to bear the severe strain put upon it. If the new metal fails, his case falls to the ground; but it is surely worth a trial.

"There is, however, another experiment possible to be carried out with the two costly guns now in the hands of the authorities. Mr. Whitworth insists that flat-headed shot or shells, very long, and therefore containing a large bursting charge, are the proper projectiles to fire at iron plates, especially when the target stands obliquely to the line of fire. We have inspected certain plates containing holes pierced or punched by flat-headed projectiles fired from the Whiteworth 1¾-in. gun of 7 cwt. A plate of equal thickness with the shell was completely pierced at an angle of 45°, and with a charge of 10 oz. At an angle of 65° the shell did not pass through, but made a ragged hole. At right angles it passed easily through a 2½-in. plate. A service gun of equal weight would have a calibre of 3 in., and be capable of piercing at least the 2½-in. plate directly, probably a 3-in. plate. But it is not with these tiny pieces of ordnance that artillerists' attention is now chiefly occupied, at least out of England. The great point is to make guns and projectiles that will pierce iron-clad ships at all sorts of angles. The rough-and-ready rule with our service gun is, that a shot or shell will pass through an iron plate somewhat thicker than its own diameter; a 9-in. projectile through more than a 9-in. plate, etc. But Mr. Whitworth contracts the diameters of his projectiles for the same weight both of gun and ammunition. He makes his shells long and narrow, so the rough rule has no application to them. We should very much like to see what target would be pierced by the Whitworth guns with Whitworth flat-fronted projectiles, and at what angle. The experiment is surely worth the small sum of money it would cost. It is of no use to point to experiments made with 2-in. guns. All working artillerists have been disappointed, over and over again, at the difficulty of getting big guns to do as well, in proportion to their bulk, as small ones. But there are the big guns; why not try the long, flat-fronted projectiles? When the question comes before Parliament it is sure to be made as foggy as possible. Let us try for once to state it clearly.

"Whitworth's system of artillery consists essentially in small-bore guns with long projectiles. The twist of the rifling must be rapid, because otherwise the long projectiles would turn over. All this involves a great strain upon the interior of the gun. Until now he has not succeeded in making heavy guns to stand this strain, except in small numbers, at a prohibitory price. He now asserts that he has found the material he has so long sought; but there is, as yet, no heavy gun in existence made of this material. We say, let him make one, and let it be tried. Then, there is that other question of his shells, which has nothing to do with the gun question, and may be settled by firing some projectile out of the costly pieces now in possession of the Government. If the shells succeed, it will be interesting to know whether Mr. Whitworth can really make guns at a reasonable price

capable of firing them. Then comes the last question, perhaps more difficult still to answer: Where can such guns be placed without involving such a complication of ammunition and stores as would be detrimental to the public service? We hold that Mr. Whitworth has made out a case for experiment."

THE COMBUSTION OF GUNPOWDER.

From "The Engineer."

The questions, What are the combustions of gunpowder? and are these constant for all pressures under which the powder may be exploded? have been investigated by two observers, who arrived at somewhat discordant conclusions. Craig maintained that with varying pressures varied products were formed. Von Karolyi, on the other hand, believed the composition of the solid residue to be but slightly dependent on the manner of the explosion. The subject has recently been reconsidered in Germany by Federow, a lieutenant of artillery, the results of whose experiments confirm the view held by Craig.

He prepared the residue by firing powder in a pistol attached to a glass tube 4 ft. in length, and likewise by using a brass cannon, a 9-pounder, each charge of which amounted to 3 lbs. of Russian powder. The powder and the charcoal it contained had the following percentage composition:

Gunpowder.		Charcoal of Gunpowder	
Saltpetre....	74.175	Carbon........	72.5
Charcoal....	14.835	Hydrogen.....	2.9
Sulphur.....	9.89	Oxygen........	22.3
Water.......	1.1	Ash...........	2.3
	100.000		100.0

The residue, after explosion, was dissolved in water and separated from the charcoal and sulphur by filtration; the filtrate was digested for several days with carbonate of cadmium and repeatedly shaken. From the amount of sulphide of cadmium formed, the quantity of sulphide of potassium in the specimen was calculated. Of the other potash salts the hyposulphite was determined by precipitation with nitrate of silver, the sulphocyanide by Bunsen's color test, the carbonate by precipitation with chloride of manganese, and ignition in the form of $Mn_3 o_4$, and the unchanged nitrate from the loss.

Below are the names of a number of analyses made on this principle:

Percentage Composition of Dried Residue.

	Blank charge of 0.75 grammes.		Blank charge of 1.5 grammes.		Cannon charge 8 lbs.	
Sulphate potash.........	48.25	47.61	40.83	43.28	15.00	15.15
Carbonate potash.........	23.44	21.13	30.96	31.9	37.00	36.2
Hyposulphite potash.....	16 53	17.03	19.32	17.74	38.28	7.44
Nitrate potash..........	5.81	5.66	2.79	1.73	....	....
Sulphide potassium......	0.97	0.51	2.49	1 67	8.18	39.55
Sulphocyanide potassium	0.54	0.51	0.56	0.50	0.83	0.33
Sulphur.................	0.38	4.49	3.05	0.22	0.00	0.00
Charcoal................	4.08			2.9	....	1.02
Sand, oxide copper, etc..	....	....	....	....	0.82	0.12
Carbonate ammonia......	Traces.		Traces.		....	....

These numbers unquestionably show that by increasing the charge, the decomposition of the powder becomes the more complete. The greater the pressure during explosion the less the amount of unchanged gunpowder found in the residue, and the richer the latter is in sulphide of potassium and corbonate of potash, while its proportion of sulphate of potash is in like manner diminished. With increased pressure the yield of hyposulphite likewise falls.

Whatever prolongs the combustion operates like an increase of pressure. Such a condition can be brought about by mixing the powder with some fatty substance. A blank charge of 1.5 grammes of a mixture of 100 parts meal powder and 0.5 of stearic acid, left a residue composed of sulphate of potash, 31.57; hyposulphite, 22.25; carbon, 39.09; sulphide, 2.01; sulphocyanide, 0.74; charcoal, 4.02; sulphur, 0.32. The amount of hyposulphite had therefore increased, and that of sulphate decreased.

In an experiment with the cannon, 100 parts of anhydrous gunpowder left 49.61 per cent. of solid residue; whence it may be calculated that one gramme of material yielded in this case 0.039 grammes of aqueous vapor, and 258.7 cub. cent. of gases, made up of 82.6 cub. cent. of nitrogen, 162.1 cub. cent. of carbonic acid, and 14.0 cub. cent. of sulphurous acid and oxygen. Almost all the carbon,

therefore, is converted into carbonic acid, and by combustion under pressure the temperature will be higher than in cases where small quantities are exploded under ordinary conditions.

Federow considers his experiments demand another interpretation of the phenomena attending the firing of gunpowder than those proposed by Bunsen and Schischkoff, and proposes the following scheme as the more correct one :

When powder is fired, several successive reactions take place. The sulphur ignites, forming sulphate of potash. The excess of oxygen converts a part of the charcoal into carbonic acid, which escapes with the nitrogen, whilst the remaining carbon reduces the sulphate to carbonate, hyposulphite and carbonic acid (or carbonic oxide).

I. $KNO_6+S+C=KSO_4+N+CO_2$.
II. $2KSO_4+2C=KS_2O_3+KCO_3+CO_2$.

If the powder does not contain the sulphur required by the normal composition (KNO_6+S+3C), as is the case with the Russian gunpowder, and that used by Bunsen and Schischkoff, there is produced in Reaction I. carbonate, in addition to sulphate. During explosions in open tubes Reactions I. and II. only occur. If the combustion take place under pressure, however, the excess of carbon produces a further effect by causing reduction:

III. $2KS_2O_3+3C=3CO_2+2KS+2S$;

and the sulphur thus set free can act on the carbonate in Reaction II. The hyposulphite, moreover, it is known, cannot withstand a high temperature, and the sulphur will affect the carbonate according to the following equation:

IV. $4KCO_3+4S=KSO_4+3KS+4CO_2$.

And here, again, by secondary reactions, sulphocyanide is produced.

These views Federow confirmed by experiment. It follows from the composition of the powder employed, that according to Equation I., 100 parts of material will at the first instant produce 67.9 parts of residue, consisting of 54.4 of sulphate, 8.1 of carbonate, and 5.4 of charcoal, or in percentages, 80 sulphate, 12 carbonate, and 8 charcoal. But in the fifth experiment quoted, 15 per cent. of sulphate were found, and 65 per cent. of this salt had therefore been decomposed. Now from Equation II.,

$2KSO_4 : KCO_3 :: 174 : 69$;

65 parts of sulphate, therefore, correspond with 25.8 of carbonate. Consequently the total amount of carbonate should be 25.8+12.0=37.8, and the direct result of the experiment gave the number 37.0. In like manner are the other analyses of the powder residues capable of explanation.

FILTRATION OF WATER.

From "The Building News."

The old-fashioned way of filtering water by introducing it underneath the filtering materials, and, by the pressure of an external head, forcing it upwards through gravel and sand, has been given up. All engineers now adopt the system first introduced about 30 years ago by the late Mr. James Simpson at the Chelsea Water Works, when those works were situated at Thames Bank—viz., the downward, instead of the upward system.

The objection to the upward system of filtration is that the mud, lodging in the spaces provided for it underneath the filtering materials, cannot be got at for removal conveniently, and mixing itself amongst the gravel and coarser sand, it fouls them, and spoils the action of the bed.

At first sight, and without taking into consideration these objections, it seems an attractive feature of this method that the water bubbles up through the sand bed very much after the manner of natural springs—the dirty water is hidden from sight and only the clear water appears ; whereas, in the downward system, the dirty water only appears, and the pure water passes out of sight. In real efficiency, however, the latter method is much to be preferred.

The downward system has for its object the arrest on the surface of the sand, of all matter in suspension in the water, where it can be easily got at for removal when necessary, and being so arrested on the surface it never gets into or amongst the gravel or the coarser sand. These

materials, therefore, never require removal. All that is necessary is to scrape off from the surface of the sand the mud there deposited, as often as may be necessary, the period varying with the state of the water before filtration. The Thames water, before the works of the London Water Works companies were removed above the tideway, was constantly turbid, and in those by-gone days the filter-beds required to be shut off and cleaned at very short periods of time; but now that the water is taken above the tideway, although more sewage is poured into the river than formerly, the water is seldom turbid, except when the river is in a state of flood; and the periods of shutting off the filter-beds for the purpose of removing the mud deposited on the surface of the sand are greatly extended.

A rough preliminary process of filtration, or straining, is often effected by vertical filters or strainers; sometimes by a thickness of two or three feet of fine gravel contained between walls of brickwork with open joints, or more often by copper wire gauze held in wooden frames, and removable bodily for cleansing; while, when the gravel within walls requires cleansing, it has to be removed by the usual process of excavation. The copper wire gauze in the straining frames is usually of the fineness of about sixty strands to the inch, and is protected from injury by a coarser kind of iron wire netting of about 1½-in. mesh. The frames are held in their upright position in grooved standards or pillars of either cast-iron or masonry. It is desirable that the water should pass very slowly through the strainers, and without force, in order to prevent the flow of water carrying with it the solid particles in suspension in the water; indeed, slowness of motion is an essential feature in all processes of filtration.

In constructing a filter-bed the first thing to be done is to provide a sufficient area of ground to allow of the area of the surface of the top sand being sufficient to allow the required quantity of water to descend at a rate of not more than 6 in. per hour. Thus, every 100 square feet of filtering surface will pass 50 cubic feet of water per hour, and the quantity required to be passed through being known, the requisite area is thereby ascertained.

The bottom and sides of the filter-bed are made water-tight, usually by puddling them with clay, well cut, cross cut, and trodden, with the help of water to facilitate the work; but it is necessary to guard against using too much water, otherwise the structures afterwards to be erected upon the puddling will be subject to displacement. The thickness of puddle is usually about 18 in., and this should be worked in three layers, the tools used for cutting the clay being not less than 10 in. long, and they should be driven completely through the second and third layers and well into the first and second respectively.

In point of economy of construction, and where sufficient land can be easily acquired, an excavation of the ground, having slopes of two horizontal to one vertical, the excavated material being embanked round it, is preferable; but there are situations in which, for want of room, vertical walls have to be resorted to, to economize space. In the former case the slope of the excavation is cut down in level benches or steps to prevent the clay puddle that is to be placed upon it slipping down, or "spewing out."

The bottom and sides of the filter-bed having been rendered water-tight, it is usual to cover over the puddle with concrete to the depth of about 6 in., to form a foundation for the brick or other paving with which the filter-bed is lined. Where the whole of the space of ground at command is required for the filtering area, vertical walls are employed to sustain the sides of the filter-bed. They are sometimes arched on plan, with counterforts, whereby the wall material is economized, or, else they are made straight, as ordinary retaining walls, with counterforts behind.

There is a third method employed, where the space, although limited, admits of some margin for slopes, and where gravel or other material for concrete is abundant. It consists of walls of concrete with a slope on the face of about 1 to 1, while the back, if the ground is of a stiff nature, as clay or marl, is stepped.

The concrete is usually faced with brick on edge to protect it from the action of frost, which would gradually wear away its surface. Ice formed merely on the surface would fall harmlessly away, but ice formed within the interstices of the

concrete would, by its expansion, disrupt it and gradually wear it away.

For continuous working it is necessary to make the filter-bed in two divisions. It is better, except for the matter of expense, to make it in three, or even four; but it must be made in at least two divisions, in order that one may be shut off for the purpose of having the deposited matter removed from the surface of the sand while the other is in action.

The bottom and sides of the filter-bed having been formed in one or other of these ways, a brick drain with open joints, or, if the filter-bed be small, a perforated pipe is laid along the centre, and from it branches of perforated pipes, or other kind of perforated drains, are laid with a rise towards the sides, and from the upper ends of these branch drains air pipes are carried up the slopes, or the walls, as the case may be, terminating above the water level. Their ends are often covered with ornamented cast-iron perforated caps. These pipes are for the purpose of allowing the air contained in the drains and the interstices of the gravel, and which is displaced when the filter-bed is charged with water, to escape through them. Some engineers dispense with air pipes, but it is at the risk of a displacement of materials in the bed.

The drains having been laid in, and the body of each pipe packed up on each side with gravel to prevent its lying hollow on the floor, and so being liable to fracture by the weight of materials above it, the spaces between the drains are filled in with gravel or broken stone of the size of hens' eggs, and more material of the same size filled in, so that over the highest parts of the drains there shall be a depth of not less than 6 ins. of this coarsest material, the surface being brought level throughout.

Upon this first layer of materials another of 6 in. in thickness is laid, of finer gravel, of the size, say, of small walnuts. On this, again, a layer of bleached and perfectly clean shells, 3 in. or 4 in. in thickness, is laid, cockle shells being the more generally employed. Some engineers deny that shells are necessary. Perhaps they are not. Their purpose is to completely separate the finer material lying above them from the coarser beneath them, and to prevent the one running in amongst the other; and any other method that prevents this mixture equally well answers the purpose; but without shells the several layers have to be graduated by smaller degrees, and so a greater number of layers of different degrees of fineness employed, while shells act at once as a complete prevention of the mixture of the sand with the gravel.

Upon the shells a layer of coarse sand 4 in. or 5 in. in thickness, is laid, and finally a depth of not less than 2 ft. of fine sand. It depends on circumstances whether a depth of 2 ft. is sufficient, or whether 3 ft. should be laid on. The oftener the filter-bed requires cleaning, according to the turbidity of the water to be filtered, the greater the thickness should be, for on each occasion of cleaning, a portion of sand is removed with the mud, and the depth of it gradually reduced. It should never be reduced to less than 1 ft. in depth.

This fine sand should not be too fine. Some engineers have aimed at procuring the finest sand that could be had; but there seems to be a little mistake in this, for sand a degree coarser will allow the descent of the water more freely, and at the same time arrest the mud equally well; for the action of the sand on the water, or rather on the particles of solid matter it contains, is not limited to an arrestment of the solid particles on the surface, but acts under the law of aggregation; the particles of sand, being larger than the particles of mud, attract them to themselves during the passage of the water through the first inch or so in depth of the same, and it is not until the interstices of these grains of sand become choked that the filtering action ceases, thus allowing the filtration to go on for a longer period than it does when the finest sand is used; and as (although the mud does not penetrate the finer sand so far as it does the sand not so fine) the mud cannot be removed from the surface without taking with it some small depth of sand also, it is more desirable to take the benefit of this action of aggregation of particles, and so obtain a longer period of action of the filter-bed.

All the materials must be washed perfectly clean before they are deposited, and this is best done by a hose and jet under a powerful head of water, or under its equivalent, great pressure. The sand is readily washed in this way by allowing it

to run gradually into a wide trough, set in an inclined position with its lower end open, through which the water runs away to a drain provided to carry it off, the jet of water being directed against the sand in the trough from the lower end, and its action continued until the water runs away clear.

The finished surface of the sand should have a slight inclination, and the supply pipes should enter at the lower end. The ends of the supply pipes should be enclosed by troughs, over the edges of which the water flows on to the sand, and as this point of entry is the lowest part of the surface of the sand, the water fills the space appropriated to it without disturbing the sand.

When the action of any division of the filter-bed has gone on long enough, the supply is stopped and the water allowed to sink away, all but the last few inches in depth, which would be so long in running off through the sand that a drain pipe is provided to carry it off from the lower end of the bed. This drain pipe has several inlets, surrounded by wicker baskets or similar protection, to prevent the sand entering the pipe. As to the depth of water to be allowed over the sand, the late Mr. Simpson allowed from 4 ft. to 5 ft.; Mr. Hawksley allowed 2 ft. at Leicester; while Mr. Bateman allows only 1 ft. But these differences are not very important. It is the difference between the level of the water in the filter-bed and that in the filtered water well which governs the rate of speed with which the water passes through the filter-bed, and not the mere depth on the bed. If one of these depths be preferable to another, the greater one is perhaps to be preferred, because it admits of a more powerful draught on the water, in any case of emergency for a short time, while, on the other hand, there is a saving of the materials of construction by making the space above the sand shallower.

These are the principles on which filter-beds for the water supply of towns are constructed, but for smaller quantities of water, various kinds of apparatus have been devised, through which water is forced, and in a measure clarified; but the very fact of forcing the water through being necessary, indicates a too small surface of filtering medium, and consequently an early stoppage of the pores of the material.

There was a filter in use in the woollen districts of Yorkshire, which was filled with shoddy, a kind of pulp of woollen rags, which clarified very dirty water well enough for a short time, but the constant stoppages for cleaning made it very inconvenient.

Then there are other substances which act chemically on water, but they are not employed on a large scale. The substances that have been used are animal charcoal, vegetable charcoal, silicated carbon (so called), and magnetic carbide.

Dr. Letheby says animal charcoal possesses the power of bringing the oxygen dissolved in the water into chemical union with organic matter, and so destroying it, especially when the organic matter is in a state of decay and in an unwholesome condition. A certain time is required to allow the water to remain in contact with the charcoal; it must be in contact for a minute at least. A cubic foot of animal charcoal weighs from 50 to 52 lbs., and holds within its pores four gallons of water; and, therefore, allowing one minute for contact, water could not be filtered through it at a greater rate than four gallons per minute per cubic foot. The thickness of the charcoal bed is of little moment; it is the quantity of charcoal to the quantity of water that is to be considered. It is found that water cannot be forced through a filter containing 80 lbs. of animal charcoal, so as to be effectually purified at a greater rate than 400 gallons a day, whereby the water is in contact with the charcoal, on the average, during a working day, for six or seven minutes. For house cisterns, animal charcoal is very valuable, and is a safeguard against the presence of organic impurities in water.

Dr. Frankland agrees with Dr. Letheby as to animal charcoal, but says that vegetable charcoal is inert in its action on organic matter.

Mr. Thomas Spencer introduced the magnetic carbide, and has applied it on a tolerably large scale at Wakefield, where the water is very impure before filtration, containing large quantities of sewage; and so far as is at present known, this substance and animal charcoal are the only two of the four named that have had any success, even on a small scale; but

they are expensive processes, and it seems that it would be more economical to go to the expense of keeping sewage and other contaminations out of the water altogether than to employ these methods of purification.

It is obvious that where water for the supply of a town is taken from a public river, it is necessary to filter it before delivery to the houses; but it is not so obvious that filtration is necessary or desirable where the source of supply is an uninhabited hilly district. The water supplied to Manchester is not filtered, except through copper-wire gauze strainers, neither is that supplied to Glasgow; yet it is bright and sparkling when not tinged with the color derived from the peat that lies in patches within the drainage area. And to remove the color derived from peat is very difficult, if not impossible, by filtration on a large scale. Filtration of water, while removing impurities, renders it in a measure vapid, and although the presence of salts of lime in certain hard waters preserves its agreeable taste even after filtration, it was probably a wise foresight that led the engineer of the works above named to dispense with filtration, the water at both places being of a very soft character.

The well-known household filters all depend for their efficiency on animal charcoal—that is to say, it is generally understood that they do, but some of the "patentees" make a good deal of mystery about what their efficiency depends on. The different forms of these filters, however, probably constitute their only difference. The form adopted by the Water Purifying Company of the Strand, London, is a good one, consisting of a charcoal filter placed inside the house cistern. The water passes upwards through the filter and through a pipe led from the top of it over the side of the cistern and down the outside to a level below the water level of the cistern, so that the pipe becomes a siphon. A recent improvement in Mr. Lipscombe's filters consists in adding to the cistern a dirty-water pipe, through which water is drawn for purposes not requiring clean water, by which means the accumulation of dirt under the filter is prevented, the pipe being so connected that the cistern water is drawn through the space beneath the filter when the tap is opened.

AMERICAN ENGINEERS IN INDIA.

From "Engineering."

Had Lord Mayo's recently expressed intention to commence the extended railway system of India upon a new model, and that model American, and of soliciting American engineers to come and teach the Public Works Department how to build cheap railways, been announced a few years ago, opinions so heterodox as must have led to those conclusions would have been denounced with indignation, not only by English engineers, but in England universally. Only a short time since, it was popularly understood that whatever was good in American railway practice was not new, and that whatever was new was not good; that American lines were loosely thrown together, haphazard, without surveys, without grading, without ballast or drainage, over prairies where the grass was scarcely disturbed in laying the track, through forests cleared to a width barely sufficient for the passage of trains, round mountains, in curves laid out by eye, across streams on perilous wooden structures doomed to conflagration. And over these rough roads it was deemed impossible to ride even for a limited period with safety. If collision were happily avoided, it was only that the train might leave the rails and dash itself into a wreck, or crush through one of the fragile viaducts, or fall down a bank, to resolve itself into a burning mass of carriages at the bottom. But though popular ideas move slowly, they gradually grasp unmistakable facts surely, and as the mists of uncertainty and ignorance pass away, such facts remain behind, and retain their unmistakable outline. So by degrees the true knowledge of American railway practice has been forced into the public mind, until at last it is being understood that in constructing railways suited to their peculiar requirements, the United States engineers have done at home what we have hitherto failed to accomplish

abroad, and it is even considered wise to turn to them for assistance in the formation of our Indian lines. The absence of much real and definite information upon American railway construction, and the existence of so many vague and monstrous statements as to its principles, and the recklesness which attended the formation of works, fostered the prejudice which almost as a thing of course existed against a Transatlantic system. But great undertakings, triumphantly accomplished, stand out in bold relief, and the completion of the Pacific Railway disposed at once and for ever of most of the doubts and prejudices existing. The Americans had made the longest line in the world with unequalled rapidity, and so brought the western seaboard of the continent within 17 days' journey of Liverpool. For the rest, the constantly repeated examples of American railway enterprise and skill, and the descriptions and illustrations of the leading United States railway works in our columns, have succeded in conveying to the general public a clear conception of the every-day practice in the States.

The successes which have attended the efforts of American engineers in establishing a vast network of lines connecting far distant towns, and opening up remote eligible lands which lay beyond, hopelessly unprofitable tracts, form a strong contrast to all that we have attempted in our colonies, and especially in India, where an extensive mileage has been constructed, although only a very small proportion of all that is urgently required. And these latter, built at a cost more than double of their original estimates, present work which, for flimsiness of construction and carelessness, can hardly be surpassed even in America. The excessive cost of their formation has thrown a burden upon the country, and hindered the cause of railway extension in India; in other words, it has checked the employment of armies of native workmen; it has prevented the development of the country; and it has deprived India of the means of access and free internal communication necessary to all countries, but of vital importance to a military settlement. A costly experience has therefore shown that the system hitherto adopted has been a failure, that the enterprise of private companies, however serviceable for pushing forward works, has proved entirely non-successful under the guarantee system. On the other hand, the competency of the Public Works Department has not been brightly illustrated by the conduct of undertakings under its charge, without taking into consideration the bitterness and jealousy which have split this section of the Government staff into schisms and internal antagonism, and which would promise but little for the economical and rapid progress of work if it were carried out by the joint efforts of military and civil engineers.

In this difficulty the plan has suggested itself to introduce a new system, to be carried out by new engineers, whose training and experience have taught them to observe rigid economy on the one hand, and to push work to completion with the utmost rapidity on the other. Hence we are told the American system is to be tried, and by American engineers.

In taking this step we believe the Indian Government to be hardly nearer to the real solution of the problem than in the old days of private companies and guarantees. Long ago we pointed out, and have often repeated our assertions and arguments in favor of the American system of railway construction being adopted in India and our other colonies. It is exactly suitable for the purpose. Having to run for hundreds of miles, it may be through unprofitable country to ultimate objective points, it follows that such lines should be constructed as cheaply as is consistent with safety and moderate speeds. These are not permanent roads; they are but the precursors of the more durable lines—the pioneer ways by which all parts of the country may be united, and which, as the growth of trade and the value of the lands increase, will be slowly reconstructed solidly and at a greater cost, so that ultimately the trunk lines of the future railways of India will be what engineers intended the railways to be in the outset. This is the whole secret of the so-called "American railway system," to construct only such works as are absolutely necessary, and to construct them under proper organization.

But the services of American engineers are no more indispensable for carrying out this system than are the labors of United States citizens for the manufacture of American cloth; and, while it is probable that a full staff of Transatlantic engineers

transported to India would find themselves infected with the evils of the existing regime, it is certain that if a few only were employed any benefit expected would be simply lost in the preponderance of opposing views and conflicting practice.

It is absurd to imagine that the American engineer possesses in himself any special capacity differing so widely from that of his English professional worker, so as to make the former naturally suited for carrying out work better than the latter can hope to do. Training, experience, and specialty of employment do much; but we venture to say that there is no average English engineer who cannot do as well or better than the average American engineer, provided he were relieved from the tedious trammels of routine, and left to carry out work with a similar freedom of action. That the principle and not the individual is at fault is shown by the readiness with which Englishmen occupying professional positions in America and Canada fall into the admirable and national system which rules there.

Many of the formidable items which have burdened English railways, and weighed so heavily upon our colonial lines, are unknown in the States. Costly law charges, consulting engineers' heavy fees, and palatial offices are unknown. The engineer's staff is not so large, his remuneration far smaller, and yet his duties are more onerous; he takes the field more actively, he saves his principals many heavy charges for contractors', engineers', and agents' services; in short, the superfluous costs which have made many of our undertakings insolvent at home and abroad are unknown in the States, as they ought to be at all events upon our colonial work. An American engineer would be incredulous if he heard that the maintenance of the Public Works Department amounted to so large a percentage of the amount expended.

The solution of the Indian railway difficulty does not seem to lie in the transfer of its works to American engineers. So doing would only have the effect of complicating the existing difficulties, which unfortunately are now serious enough, while there would be no security for more economical construction. But what is wanted is the adoption of the American system in its constructive principles and its organization; that system is well understood, and may soon become familiar to all engineers employed by the Government, and being understood it may, by official help, be efficiently carried out. But it must be remembered that it would clash with the present military regime, that much routine and formality would have to be swept away, and give place to a freedom of individuals and a personal responsibility which would be probably distasteful to the Public Works Department.

And before any earnest service can be be effected, the difficulties between the civil and military branches of the service must be removed, the whole of the principles and practice which have guided the Department should be thoroughly investigated, and the causes which have led to the perpetration of so much bad work, and so much costly work, must be ascertained. This done, the inherent evils of the Department would be made known, and the path to real reform would be then open. But until defects are thoroughly brought to light, remedies cannot be instituted, and in the meantime the partial employment of American engineers upon Indian railways would prove rather an evil than a benefit.

To Render Timber Incombustible.—This has hitherto been done by saturating the wood with some soluble silicate. A new method is described in the "Neues Jahrbuch fur Pharmacie." Herr Reinsch states that, having been reqested to report to a fire insurance company about the best means of preventing timber bursting into flame, he experimented with various salts, and at last came to the conclusion, as the result of his experiments, that impregnating timber with a concentrated solution of rock-salt is as good, if not better, a preservative against its bursting into flame as water-glass (silicate of soda), while the price of the former salt is, of course, only a mere trifle ; moreover, rock-salt thus applied to timber is a preservative against dry rot and noxious insects. The author recommends the use of salt water, that is to say, a solution of rock-salt of moderate strength, for the use of fire-engines during a fire, as by far more effective than water; but in order that the salt should not injure the working parts of the engines, they will immediately afterwards have to be played with fresh water again.

IRON ARCHES.

From "The Mechanics' Magazine."

The adoption of cast and wrought iron archers and girders for the purposes of railway traffic was a sad blow to the hopes and expectations of the advocates of the old stone type of construction. Nevertheless, with a laudable desire to make the best of their dissappointment, they comforted themselves with the idea that stone bridges would still be employed for ordinary roads, and in other situations where the limitations imposed upon the span, headway, rise, and load, were not of the same stringent chzracter. Latterly, however, these pleasing illusions have been dispelled. Bridges have been built over roads, rivers, and in other localities where their duty was not to carry locomotive traffic, and iron, either cast or wrought, has been the material selected. The recent completion of new Blackfriars Bridge affords another instance of the substitution of iron for stone, and in all probability another arch of the latter material will never throw its shadow on the waters of Old Father Thames. Omitting other considerations which are foreign to the comparison, what is the chief, the fatal objection, to an arch of stone? In a word, it is the rise. It is absolutely necessary to adhere to a minimum proportion of rise to span, and this adherence becomes impossible under certain conditions of headway and traffic. Engineers are therefore compelled to seek, either in another material or another principle of construction, for those qualities which they fail to find in that formerly in use. It is true that in arches of iron, either cast or wrought, there is also a limit to the proportion of rise to span, but the ratio is a great deal smaller than in those of stone. Moreover, by special treatment the rise may be confined to points not very remote from the springings, and the crown of the arch be practically perfectly flat. No such a disposition is practicable with stone or brick arches. This adoptiɔn of a flat crown was very successfully carried out by Mr. Page in the construction of the present Westminster Bridge. It was effected by introducing a horizontal wrought-iron plate girder for a certain length along the crown of the arch, and bolting it to the haunching or springing segments, which are of cast-iron. The span of the largest arch is 120 ft., and the length of the wrought-iron girder introduced at the crown 70 ft., so that the actual rise of the arch does not increase beyond a distance of 30 ft., from each springing.

So far as mere span is concerned, where there is nothing to prevent the proper rise being obtained, a stone arch can bear a very favorable comparison with one of iron. The Grosvenor Bridge over the river Dee, near Chester, has a clear span of 200 ft., and is the finest stone arch in existence. On the other hand, the central arch of Southwark Bridge is 240 ft. in span, and, in spite of its unscientific design and distribution of material, is yet a fine specimen of cast-iron construction. Its great span and rise give it a bold outline, which unfortunately is very much marred by the bad appearance of the piers, which are little better than those supporting its neighbor of Vauxhall, higher up the stream. The expectation that, with the substitution of iron for stone in the construction of arches, much larger spans would be reached, has not, with one or two exceptions, been fulfilled. With the exception of Southwark Bridge and another, to which we shall presently allude, all the arches of the iron bridges over the Thames are inferior in span to that of the stone structure over the Dee. The truth is, that the mania, if the term may be used professionally, for large spans has died out. Unless there are no other means available, engineers do not advocate the employment of very large spans in iron-work. The reason is, that the weight, and consequently the cost, of the superstructure increases in a very disproportionate ratio to the span. There is manifestly, therefore, a certain proportion of span and a certain number of piers—or, what is the same thing, a certain number of spans—which will fulfil the conditions of maximum economy. Colonel Kennedy was the first to reduce this principle to practice, and adopted, with one or two unavoidable exceptions, a uniform span of 60 ft. for the spans of the bridges along the whole of the Bombay and Baroda line in India. There is very little doubt but

that the span of 60 ft. is too small, and greater economy would have resulted from adding ten or even twenty additional feet to it.

In one of the first attempts to substitute cast-iron for the older material—stone—in the construction of arches, the transition or the difference was very small, and consisted solely in the adoption of a different material. The same form and the same principle of voussoirs or arch stones were retained in the building of the Sunderland Bridge, with the exception that they were formed of hollow cast-iron, and bolted together through flanges cast for the purpose. This was clearly a servile imitation of what had been already accomplished with stone, and iron cannot be correctly said to have been substituted for stone until the "rib" principle came into use. Numerous arches were constructed with cast-iron ribs, in which there was not the slightest attempt at accurate designing or scientific and economical distribution of material. So long as they were made strong enough, they answered their purpose thoroughly, and do so still at the present day. The difficulty of obtaining sound and reliable castings of large size induced engineers to construct arched ribs of wrought-iron. The two best examples of this nature are the Victoria Bridge, carrying the railway over the Thames at Chelsea, and the magnificent structure recently inaugurated by Her Majesty at Blackfriars. Theoretically, cast-iron, from its great resistance to a compressive strain, is the most suitable and economical material to employ for the construction of arches, and it might be used in that situation a great deal oftener than it is. Engineers have conceived a bad opinion of cast-iron from the failures with which it has been attended in some isolated instances. At the same time they altogether overlook the important fact that these failures were due, not to the unsoundness or weakness of the material itself, but were entirely owing to the circumstance of it being placed in a situation and subjected to strains for the resistance of which it was not adapted. It is very probable that, by a pardonable *esprit de corps*, engineers prefer to lay the blame of these failures upon the material rather than upon the designers. But, as we have now arrived at a more scientific period, and are, from past experience, fully enabled to form a correct estimate of what may be fairly and reasonably expected of cast-iron, there is no necessity for refusing to accord to that metal the merit which unquestionably belongs to it.

There are abundance of cast-iron arches carrying the various railways over the suburban roads of our metropolis, which have done duty for 20 or 30 years, and are "as good as new." There can be no question of their strength and stability, and it is difficult to comprehend why some engineers are positively afraid to erect similar structures, but, in their place, substitute others of a more expensive character. Where the span is large and the bridge intended for railway purposes, it is a question for consideration whether wrought-iron should not be used instead of cast, especially if the rolling load bears a very large proportion to the fixed weight of the bridge. But in a bridge intended for ordinary road traffic, where the conditions of the ratio of the fixed to the rolling load are inversed, there is no valid argument against the employment of cast-iron within proper limits. The rejection of cast-iron in situations where it is peculiarly applicable, is a piece of professional pusillanimity which has had its origin in the ignorance and incompetency of some of the members.

A French writer calculated that, at the commencement of 1867, there existed in the world 2,814 light-houses, or phares, of more or less importance, viz., 1,785 on the coasts of Europe, 674 on those of America, 162 in Asia, 100 in Oceania, and 93 in Africa. As regards Europe, the best-lighted coasts are those of Belgium, France following immediately afterwards. Then come, in the order in which their names are given, Holland, England, Spain, Prussia, Italy, Sweden and Norway, Portugal, Denmark, Austria, Turkey, Greece, and finally Russia. Besides Europe, the best-lighted coasts are those of the United States, which have one light for every 20 miles, whilst the Brazilian coast has only one light for every 87 miles. Of the 2,814 in existence at the commencement of 1867, about 2,300 have been established since 1830, while the power of the greater part of those existing prior to 1830 has been increased.

ON CERTAIN ECONOMICAL IMPROVEMENTS IN OBTAINING MOTIVE POWER.

BY MR. RICHARD EATON.

Condensed from "The Engineer."

The British Association for the Advancement of Science having, in their programme for the present session, invited contributions on the momentous subject of the economy of fuel, it is conceived that some description of a discovery in that direction, called the Warsop aero-steam engine, may not be without interest.

It is now pretty generally allowed that power and heat are convertible terms, and we have it upon the highest scientific authority, that a unit of heat is equivalent to 772 foot-pounds. We are further informed that one grain of coal produces by combustion sufficient heat to raise the temperature of 1 lb. weight of water through 1.634° Fahr. Taking the mechanical equivalent of heat at 772 lbs. per unit, as above stated, it follows, therefore, that the combustion of one grain of coal = 1261.45 foot-pounds.

Now, with the best pumping engines, either on the "Cornish" or "Woolf" system, the average duty is equivalent to about 94,000,000 foot-pounds, with a consumption of 94 lbs. (1 bushel) of Welsh coal—in other words, 143 lbs. per 1 grain of coal, as compared with 1261.45 lbs.; whence it appears that the steam-engine, in its most improved state, is not able to develop into useful power much more than one-tenth of the mechanical power due to the combustion of coal.

As a rule, we may assume that the more distant the extremes of temperature in a thermodynamic engine, the larger will be the proportion of heat turned into power.

In the steam-engine, the extremes of temperature, or the difference in the temperature of the boiler and condenser, are not very great, and air-engines, therefore, in which greater extremes may be employed, offer certain advantages in the production of power. But in their arrangement, construction, and practical working, many difficulties occur.

The difficulties in question arise, first, from the destructive action of the heating furnace upon the generator, which, when unprotected by water, is sooner or later burnt out or destroyed. Secondly, when high temperatures of air are employed, the wear and tear of working parts becomes very great, and the difficulty of proper lubrication almost insuperable. On the other hand, if low temperatures be employed, the engine develops but little power in proportion to its size, and the consumption of fuel becomes quite as large as, if it does not exceed, that of ordinary steam-engines.

In the consideration of the subject before us, a useful lesson may be learned from the avocations of domestic life. Let the tea-kettle be our monitor. The careful housewife places it, duly cleaned and charged, upon the fire; and no matter how sharp and clear may be the draught, nor how vivid and intense the gaseous flame, no harm ensues. Let her, however, neglect to keep it replenished, and what occurs—the bottom is destroyed. The water acts as a shield or safeguard to the metal exposed to the vivid incandescence, and in the present state of our knowledge as to the structure of metals, or their behaviour when exposed to sharp heat, it is difficult to devise a better protection.

The difficulty above mentioned has hitherto proved insuperable, notwithstanding the best efforts of those apostles and pioneers of the air engine, Stirling, Ericsson, and others. All the ingenuity expended upon the designing and construction of regenerators for utilizing to the utmost the heat of the escaping air, proved, unfortunately, of no avail so long as the generator, which was the mainspring of the whole, to say nothing of the working cylinder itself, remained liable to premature destruction.

Mr. George Warsop, of Nottingham, as the son of an air-gun maker there, was born with aerial ideas, which, although his only education was received at a Sunday school, and he was sent to work at ten years of age, he turned to such good account that, before he was twenty, he had, in leisure moments, secretly constructed an air-engine. Later in life it was his privilege, whilst a working mechanic in New York, during his engagement with Mr. Ericsson, to observe the weak points in the system of that highly gifted and

persevering inventor, and after years of research, to supply the deficiencies by a marvellously simple system of mechanism, which, so far as present experience goes, promises complete success, by means which, happily for the cause of economy and progress, are compatible alike with physical science and mechanical construction.

It is proposed, first, to describe these means; secondly, to enumerate the carefully ascertained comparative results which have followed their application; lastly, to show that these results are in accordance with sound theory.

In the first attempts at practically carrying out the system, the arrangement adopted consisted of an ordinary high-pressure engine, with vertical boiler, as used in the midland counties, where fuel is cheap. An air-pump is added, which is put in operation by the action of the steam-engine. Thus, cold air is taken in by the air-pump, and is forced on in its compressed state, through an air-pipe, which is conducted first within the exhaust, then in a coiled form down the funnel of the boiler, then past the fire, and finally past a self-acting clack-valve, at the bottom of the boiler, into the boiling water itself. Rising naturally through the water, the air is intercepted and subdivided by diaphragms of metal gauze. Thus a two-fold service is rendered by the contact of the elements, the water becoming aërified and deprived of its cohesion, and prompted to a freer ebullition; whilst the air, on rising above the water, is saturated by the steam, and the two together pass on to their duty in the cylinder, where saturation assists lubrication. The agitation of the water prevents scaling.

The machine thus constructed, but having two air-pumps, with cam motions applied to the valves, as also to the puppet-valves of the working cylinder, gave the following results—results which, it must be admitted, were sufficiently discouraging to have deterred the inventor and his associates from proceeding further in the matter, but for their faith in the intrinsic soundness of the system, and perseverance in carrying it to a practical issue. The work had to be done under disadvantages of various kinds, on inconvenient premises, which, centuries back, were a farm house standing within the ancient walls of Nottingham; and, until the protection of the patent laws had been obtained, the original apparatus was carefully guarded in an unsuspected attic. The results I proceed to detail:

Combined Air and Steam Engine.

Coals consumed during experiment......	110 lbs.
Weight on brake......................	75 lbs.
Duration of experiment................	140 min.
Number of revolutions of brake.........	4,623
" " " per min.	33
Gross horse-power of useful work done...	182
Gallons of water evaporated during experiment............................	84

Steam Engine only.

Coals consumed during experiment......	110 lbs.
Weight of brake......................	75 lbs.
Duration of experiment................	115 min.
Number of revolutions of brake.........	5,182
" " " per min.	45
Gross horse-power of useful work done....	204.1
Gallons of water evaporated during experiment............................	66

It is needful to state that the amount of air passed into the boiler in a state of compression, was considerable, being as much as 43 per cent. of the effective cubic contents of the working cylinder, or consumption of combined fluid from the boiler. And it appeared pretty certain that the power obtained by the increase of volume of the air admitted (due to the treating of it) did not compensate for the power consumed in working the two air-pumps which forced it into the boiler. At the same time the difference in the useful effect in the two modes of working did not appear to be so great as the power required in handling the pumps led one to suppose it would be. Hence there appeared an evidence of a certain latent gain which needed only development. To effect this, one of the air-pumps was discarded, and experiments made by means of waste holes, drilled through the walls of the remaining one, to ascertain what proportion of air admitted to the boiler fully compensated for the cost of compression. And it was found that about 10 per cent. of the effective consumption of fluid in the working cylinder gave much more favorable results. At the same time the cam motions were discarded, and the air-pump valves left to their own unaided action. The results are given in the subjoined table:

Combined Air and Steam Engine.

Coals consumed during experiment......	140 lbs.
Weight on brake......................	124 lbs.
Duration of experiment................	195 min.

Number of revolutions of brake..........	8,463
" " " per min..	43.4
Gross horse-power of useful work done...	551.1
Gallons of water evaporated during experiment..............................	104.3

Percentage of gain in work done by combined engine as compared with that done by steam only, 42½ per cent.

Steam Engine only.

Coals consumed during experiment......	140 lbs.
Weight on brake......................	124 lbs.
Duration of experiment.................	145 min.
Number of revolutions of brake.........	5,942
" " " per min.	41
Gross horse-power of useful work done...	386.9
Gallons of water evaporated during experiment..............................	64

Here, although a very remarkable relative economy was apparent, it became obvious, on consideration, that danger of mistake would arise in assuming this economy as absolute, inasmuch as the duty performed, when contrasted with that obtained from engines of standard types actuated by steam, was manifestly low, and it seemed probable that, as by judicious improvement in details, the duty was made to approximate more closely to fair steam-engine duty, this relative economy might fall off considerably, inasmuch as there would be less margin to economize upon.

With the view of testing this point, and also, for the satisfaction of railway engineers, of conducting experiments at locomotive pressures, a thorough remodelling of the whole apparatus was effected. The tappet motions were thrown aside in favor of the usual slide-valve arrangement, working with a moderate amount of expansive action. The former wasteful vertical boiler was discarded in favor of a more economical one of the compound or Cornish multitubular description, so as to obtain a better evaporative duty from the coal consumed. The radiating surfaces of the cylinder pipes were re-clothed, and the feed water heated by the exhaust steam. Instead of exposing the air-pipe to the *direct* heat of the furnace, as in the former case, the air became thoroughly heated in its passage from the pump to the boiler, to a temperature of from 500 deg. to 600 deg. Fahr., by being conducted through suitable coils and pipes through the exhaust steam in the heater, and the waste heat in the boiler flues and uptake.

The general arrangement adopted will be readily understood. The air is forced by the air pump through a tube of ordinary wrought-iron, and of 1¼ in. internal diameter into coils in the regenerator, which is heated by the exhaust steam; thence in a straight line to the uptake, down which it passes through a coil into the flues beneath the boiler, and through another coil in the smoke-box; thence back to the front of the boiler and past the clack-valve, and is led down by an internal bed to the bottom of the boiler water space, where it is evenly distributed along the whole length by a perforated pipe, and the results are given in the following table:

Combined Air and Steam Engine—Open Valve Trial—Damper wide open throughout.

Coals consumed during experiment......	140 lbs.
Weight on brake......................	120 lbs.
Duration of experiment.................	234 min.
Number of rev. lutions of brake.........	22.815
" " " per min.	97.5
Gross horse-power of useful work done...	1428.05
Gallons of water evaporated during experiment..............................	131.25
Weight of fire left in furnace when engine stopped..........................	43 lbs.

Percentage of gain in work done by combined engine as compared with that done by steam only, 27.994 per cent.

Steam Engine only.

Coals consumed during experiment......	140 lbs.
Weight on brake......................	120 lbs.
Duration of experiment.................	196 min.
Number of revolutions of brake..........	17,825
" " " per min.	90.94
Gross horse power of useful work done...	1115.7
Gallons of water evaporated during experiment..............................	112.5
Weight of fire left in furnace when engine stopped..........................	28¼ lbs.

Combined Air and Steam Engine—Even Pressure Trial—Damper Varied.

Coals consumed during experiment......	112 lbs.
Weight of brake......................	120 lbs.
Duration of experiment.................	153 min.
Number of revolutions of brake.........	15,433
" " " per min.	101 nearly
Gross horse-power of useful work done...	972.55
Gallons of water evaporated during experment..............................	93¾
Weight of fire left in furnace when engine was stopped..........................	53½ lbs.

This trial was conducted on the same principle as that followed by The Royal Agricultural Society, the engine being stopped in each case when it ceased to perform ninety revolutions per minute. Percentage of gain in work done by combined engine as compared with that done by steam only, 47 per cent.

Steam Engine only.

Coals consumed during experiment......	112 lbs.
Weight on brake........................	120 lbs.
Duration of experiment.................	112 min.
Number of revolutions of brake.........	10.500
" " " per min.	93¾
Gross horse-power of useful work done...	661.69
Gallons of water evaporated during experiment	68¾
Weight of fire left in furnace when engine was stopped..........................	34 lbs.

15,433 revolutions under steam would have required 100 gallons of water.

It is right to mention that in all the before-detailed experiments the Prony brake, with the best modern improvements, was used as the measure of useful work done, and every care taken in the conduct of these trials to determine accurately the amount of water evaporated and the duty done in useful effect by a given amount of fuel. Other observations as to temperature, indicator diagrams for determining the cost of the air compression in proportion to the power developed, and various useful notes were obtained, which it would be out of place to recapitulate here at length; but all these details are at the disposal of the Association, or any scientific persons interested in the subject. Professor Tyndall has volunteered to investigate the scientific bearings of the results which have been personally observed in Nottingham by that accomplished amateur engineer, Lord Richard Grosvenor, and by other engineers, several of whom have already applied to be licensed to make.

It remains to submit to your consideration the theory of our system.

We have here a machine which, when worked as an ordinary steam-engine and boiler, performs as respectably in its brake duty as an average well-constructed commercial engine not designed to work with a high rate of expansion, and we find that the addition of the pneumatic arrangements considerably enhances the amount of its useful duty.

Let us now endeavor to ascertain in what manner the gain in question arises, premising that the following condition of things can exist only in theory.

Suppose a boiler to be theoretically perfect, wasting no heat, and its feed level maintained only just constant, the quantity of water evaporated being infinitely small, and friction of all kinds to be eliminated in the machinery. Then the power required in compressing any give amount of air at atmospheric density will be recouped by the power generated by the re-expansion of the air so condensed, action and reaction being equal.

Let us now ascertain the cost of obtaining a given quantity of steam at a given pressure, as compared with the like quantity of air at the like pressure; and, for sake of example, we will take 150 cubic ft. in each case at 60 lbs. pressure per square inch in gauge.

Here the relative volume of the steam to the water which is generated would be, in the case of 60 lbs. pressure (307° Fahr. about)=355 to 1, according to "Regnault."

And it follows that the 150 cubic ft. of steam under consideration was generated from a three hundred and fifty-fifth of its volume of water originally, or .422 cubic ft.

The weight of 1 cubic ft. of water being 62.32 lbs., the weight of .422 cubic ft. would be 26.3 lbs. Now, to raise 1 lb. water from 52 deg. Fahr. to 212 deg., or through 150 deg., requires 150 heat units; to convert it from water at 212 deg. into steam at any pressure, 966 units, making a gross total of 1116; and as the conversion thus of 1 lb. of water requires 1116 heat units, it would follow that the conversion of 26.3 lbs. of ditto would require 29,350 heat units, which is the cost of obtaining 150 cubic ft. of steam at 60 lbs. pressure.

In the case of the air, 500 cubic ft. at atmospheric density, and temperature 62 deg., would, by Marriott and Dulong's law, be transformed into 100 cubic ft., at 60 lbs. per sq. in. on gauge, supposing the temperature remained unchanged.

But this 500 cubic ft. of atmospheric air is, by the combined agency of the increase of temperature, due to compression, and the application of artificial heat in some form, brought from its original temperature of 62 deg. up to that of the boiler, viz. (that due to 60 lbs. pressure), 307 deg.; in other words, through 245 deg. Fahr.

Now the weight of 500 cubic ft. of atmospheric air = 38.05 lbs.—that of 1 cubic foot at atmospheric density, and 62 deg. temperature, being = .0761 lbs., according to Regnault's experiments. And we have seen that this 500 ft., at atmospheric density, and 62 deg. temperature, is equiv-

alent in value to 100 cubic ft. at 60 lbs. pressure and the like temperature; the weight therefore would be alike = 38.05 lbs.

The increase of volume from 100 cubic ft., due to the increase of temperature from 62 deg. to 307 deg., or through 245 deg., would be, according to the general formula applicable to the expansion of gases, about 50 per cent., or say roughly, as the volume would increase four hundred and eightieth of its bulk for each degree Fahr. increase of temperature, for 245 deg. increase the original bulk of 100 cubic ft. would be increased $\frac{245}{480}$ths, which is about 50 per cent.; the original 100 cubic ft., at 60 lbs. pressure per sq. in., now becoming 150 at the like pressure, and this weighs 38.05 lbs.

The number of units of heat which will be consumed in raising the temperature of this 38.05 lbs. of air from 62 deg. to 307 deg., or through 245 deg., the pressure remaining constant and the volume variable, as above described, will be, according to Regnault, the same as would raise the same weight of water through .278 deg.; 38.05 lbs. equivalent weight of water $\times$ 238 deg. Fahr. $\times$ 245 range through which raised = 2218.69 heat units, which is the cost of obtaining 150 cubic ft. of air, at 60 lbs. pressure, as compared with 29,350 heat units before mentioned in the case of the like quantity of steam—a very striking and remarkable difference.

Both these 150 cubic ft. are capable, when worked in a cylinder, of generating the same motive force, and are alike capable of being worked expansively; but it is an important consideration whether the loss in working the air expansively would not be greater, owing to its more rapid radiation and loss of heat, and consequent loss of volume and pressure.

Such a theoretical gain, viz., about 13 to 1, is evidently vastly far from being realized in the experimental engine, seeing that only about 13 per cent. of the whole cylinder consumption in the last experiment is passed into the boiler (in place of 100 per cent., as in the investigation above given), the remainder being supplied by the steam generated; thus, 13 per cent. *air* + 87 per cent. *steam*, and we must look to other causes, in addition to the above, to account for the economy realized in practice.

It is conceived that it is to the injection of air into the boiler that this may mainly be referred, for the following reasons: When steam is ordinarily raised from water, the heat expended is consumed partly in overcoming the cohesion of its particles, and in creating steam room for the vapor raised; and, further, in promoting the circulation of the water itself in the boiler. In all of these operations work is done, and the injection of the air accomplishes, practically, the work which, under the above mentioned circumstances, would have to be done by the heat; a much more intense and rapid circulation of the water is achieved, and the rapid ebullition and giving off of steam bubbles is greatly promoted.

Further, the air enters at a higher temperature, and its *direct* action upon the water is equivalent to an increase of evaporative surface—all the more efficient from being *direct*, instead of communicated by the conductive power of metal plates.

An experiment which has been repeatedly made goes far to confirm this view. Let the engine be running under steam, the pressure gauge rapidly falling, with the fire fast dying out. The putting the air-pump in gear will cause the gauge to mount several pounds in the course of a few minutes, and there continue for a considerable time, the engine meanwhile continuing to work as before, after checking a moment or two on first feeling the increased resistance due to putting the air-pump in action. And this result evidently shows that the evaporative duty of the boiler is increased immediately on the admission of the air, and irrespective of the state of the fire—a condition of things which is consistent with the foregoing explanation, and, indeed, scarcely perceptible of any other.

Opportunely does this discovery come in 1869, the centenary of the steam-engine.

A writer in a recent number of that valuable paper, the "Economist," remarks that "a single improvement to save 10 per cent. in fuel for the steam-engine would probably add more absolutely to the real wealth of this generation than the invention of the steam-engine itself added to the real wealth of the generation in which it was invented." After years of anxious reasearch, we now possess such an improvement, but of greater value. We are thankful for the opportunity of doing good in our day and generation.

A NEW METHOD OF UTILIZING SOLAR HEAT.

Translated from "Les Mondes."

This method is due to Mr. Delaurier, of Paris: A truncated cone, open at both ends, is silver-plated on the inner surface, and highly polished. The solar rays enter the large end, and, because of the equality ef the angles of incidence and reflection, converge at the small end. As the length of the cone is increased, the area of the smaller opening may be diminished, and the concentration of heat becomes greater. This simple contrivance, in the opinion of the inventor, may work out an industrial revolution, especially in Africa.

We quote from the inventor's description: "Heretofore we have made use of concave mirrors and lenses to concentrate solar rays. Everybody knows the difficulties attendant upon the use of large metallic mirrors having but one focus, and the great loss of heat caused by reflection.

"Lenses are not only a very bad means for concentrating radiant heat, being but little diathermic when thick, and, moreover, impossible of construction when one attempts to make them in sections.

"The process described has a further advantage in the fact that rays incident upon the surface at a small angle lose little by reflection; so that in this case almost all substances can be made good reflectors. But the chief advantage is cheapness and facility of construction. A common wooden box of the right shape, lined with tin, will be sufficient. If it is wished to get a greater concentration of rays let this pyramid be made long.

"Is it not possible by this means to obtain heat enough for ordinary purposes, especially for irrigation, by furnishing steam to engines suitably modified?"

M. Delaurier has also devised a means to prevent explosion of fire-damp, by a continual firing of the gas as soon as it is generated in small quantities in different parts of the mine. A wire runs through the mine from a Ruhmkorff coil which is kept constantly charged. This wire is cut at intervals deemed sufficient, and the ends are separated about 1 millimetre. With a coil giving a spark of 6 centimetres he cuts the wire in say 10 places in the highest parts of the mine, where the gas first collects. There is no need of a return-wire, the earth serving as well.

By this means the explosive compound of air and gas is set on fire as fast as the gas is generated, and the consequence is nothing more dangerous than a series of slight explosions. This is not very expensive; and the expense can be reduced by applying the process for a few minutes each day before the miners begin their work.

LIQUID FUEL FOR HEATING LOCOMOTIVE BOILERS—NEW EXPERIMENTS.

By H. SAINTE-CLAIRE DEVILLE.

From "Comptes Rendus" through "Polyt. Journal."

Mr. Paul Audouin has constructed a fire-hearth by which the problem of the use of petroleum, or other kinds of mineral or coal oil for heating furnaces or boilers, has been solved to perfect satisfaction. This fire-hearth is a simple chamber of masonry with a brick bottom on which the oil is dropped slowly through pipes, provided with cocks to regulate the supply of oil. The air required for burning the oil, is admitted through the holes of a perforated plate of fire-brick, standing upright, and forming the back-wall of the chamber. I have replaced this plate by a strong cast-iron grate of ordinary construction, which makes this apparatus more solid and more convenient without altering its principle.

Mr. Dupuy de Lôme and myself have used this improved apparatus with success for heating a tubular boiler on the French Imperial yacht Puebla. This boiler when heated with petroleum produced an effect of 60-horse power. We have proved by our experiments that petroleum is the

most manageable, and for Paris and many other places even the cheapest kind of fuel.

Shortly after the completion of these experiments, which were made in March and April 1868, Mr. Sauvage, Director of the French Eastern Railway, had the locomotive No. 291 put at my disposition for further trials with liquid fuel. Assisted by Mr. Dieudonné, I made the necessary alterations in the construction of the fire-hearth of this locomotive, so as to make it fit for being heated with mineral oil.

This was not a very easy task. For the combustion-chamber had to be simple in its construction, occupying as small a space as possible, and had to be constructed without brick walls or arches, which, in a machine so subject to violent concussions as a locomotive, would have involved serious dangers. Also the quantity of oil to be burnt hourly in a locomotive of 300-horse power is so considerable, and the space available for its combustion is comparatively so small, that the conditions under which the combustion has here to take place are entirely different from those existing in the preceding experiments. I solved the problem in the following manner:

1. I first experimented on a vertical grate, consisting of a row of upright bars, hollow, but open in front on the whole of their length, each grate-bar thus resembling an upright cast-iron channel. The oil is poured slowly from above into the interior of the bars, where it is evaporated by the heat existing in the fire-place. The vapors thus produced are burnt immediately in escaping from the bars, by the air which enters between the bars. The affluence of oil and air must be regulated in such a manner that the vapors burn without smoke, and that not more air is admitted than is necessary for the combustion. This condition is very important. For the principal advantage of the use of liquid fuel in regard to economy lies in the possibility of effecting a complete and perfect combustion by exact regulation, an advantage which liquid or gaseous fuel has over any kind of solid combustible.

2. The thicker and stronger the grate-bars, the better will their inside be protected against the cooling influence of the air, and the more rapid will be the evaporation of the oil. The thickness in cast-iron of the bars has to be found by experiment for each kind of oil. It must be such that the oil, in running down along the interior walls of the bars, is entirely evaporated before it reaches the lower end of the bars.

The combustion effected by this grate produces a lively, but very short flame, only one-fourth of a metre in length. At a greater distance than this the gases are invisible, though very hot, as is proved by the immediate incandescence of a strong platinum-wire, when held into them. This seems to show that the completeness of the combustion, and consequently the absence of all carbon, is the cause of the invisibility of these gases. They may in this respect be compared to the exterior part of the flame produced by a blow-pipe.

3. Whenever it is desirable to increase the surface on which the oil is evaporated, without increasing the size of the apparatus, the grate has to be laid down in an inclined position. Thus the oil has to run a longer distance, and the quantity of oil evaporated during a certain time is more considerable. The draught of the stack has then to be augmented in proportion to the greater vivacity of the combustion, so as to make the latter complete and perfect.

This kind of apparatus has to be adopted for heating locomotives with liquid fuel; the grate may be placed in an inclined position into the ash-pit. The bottom of the apparatus may be made of copper, hollow, and filled with water or arranged in such a manner as to form a part of the boiler. It is in this case advantageous to give the whole apparatus the shape of a cylinder, to avoid all even surfaces as well as all stay-bolts in the interior of the fire-box. The oil enters through a number of holes provided in the upper part of the grate; it then runs down over the grate, at the lower end of which a cast-iron projection prevents that part of the oil which might not have been evaporated from coming in contact with the bottom. The locomotive No. 291, which I used in my experiments, did not have so perfect an apparatus, not being specially constructed for this purpose. The grate had there to be placed in front of the ash-pit. The latter was closed by an iron plate, which was covered and protected by a

brick plate. The iron frame below the fire-bridge had to be protected by a brick mantle resting on an arch of fire-brick. This temporary arrangement stood very well in the trials, and was not in the least affected either by the heat in the hearth, or by the shaking of the engine, although the bricks were not of superior quality, and although the engine moved at a speed of 60 to 70 kilometres (=37 to 43 English miles) per hour. The distribution of the oil over the grate is regulated by a single graduated cock. Mr. Brisse, second director of the railroad machine-shop at Epernay, has replaced this cock by a quite simple apparatus, of which, however, I am not allowed to publish a detailed description. The principal feature is a screw with a graduated head, placed within the reach of the engine-driver.

The draught in the chimney is effected in the ordinary way by the action of the blow-off pipe.

Whenever mineral oil is used in the right way, neither smoke nor cinders are produced. When the locomotive runs at a high speed, the draught effected by the blow-off pipe is so strong, that the consumption of oil, and consequently the production of steam, can be increased at pleasure without creating any smoke.

The regulation of this fire by means of a simple cock, is so easy a work that it can be done by the engineer in addition to his other duties. The appearance of the gases which escape from the chimney, serves as a guide in this operation. The gases must have a slight yellowish tint, which shows that they do not contain an excess of air.

A self-acting mechanism can be applied to the cock to prevent all fatal consequences which might arise from a sudden and vehement concussion produced by some accident. This mechanism would shut the cock and extinguish the fire at once, thus rendering a conflagration impossible, which has often originated under such circumstances and proved highly disastrous with locomotives heated by coal.

I must here remark that only the heavy and thick-flowing kinds of mineral oil or petroleum, which are less inflammable, can be used to advantage for heating locomotives. The oil is tested by being heated to 100° Celsé, after which a well-lit link is dipped into it. If the oil is of the proper kind, the link will not set fire to the oil, but will itself be put out.

Numerous experiments were made with the above-described heating system on the French Eastern Railroad. They were conducted by Mr. Dieudonné, who afterwards communicated to me the following tables and remarks on the results obtained:

DATE.	Number of Wagons.	Gradient, Rise per 1 Metre	Average Velocity.	Total Distance.	Consum'tn of Oil per Kil're.	Weight of the Wagons.	REMARKS.
		Milli-metres.	Metres p. min.	Kilometres	Kilograms	Kilograms	
July 19...	8	0	60	18	4.70	50,000	Pretty good weather.
July 30...	8	0	60	18	4.58	50,000	Pretty good weather.
July 30...	11	0	60	18	4.71	90,000	Fine weather.
Nov. 26...	4	3.5	60	55	4.70	30,000	Very bad weather.

1 Metre=39.38 inches Eng.
1 Millimetre=.039 inches Eng.
1 Kilometre=3281 feet Eng.
1 Kilogram=2.2 lbs. avvir.

The locomotive used in these trials had but one driving axle and weighed 20,000 kilograms. Weight on the driving axle, 8400 kilograms. Size of heating surface, 60 square metres.

The best results were obtained on the 30th of July, when the engine developed about 250-horse power, or 4⅙-horse power per square metre of heating surface. This result is certainly very satisfactory.

The firing-up of the engine takes 75 min., when the blow-off pipe of another engine is used for the purpose. If the engine has to be heated up exclusively by

the draught of its own chimney, 3½ hours are necessary. The firing up of an ordinary engine with coal requires 2½ to 3 hours.

THE SUEZ CANAL.

The whole of the land acquired by the Suez Canal Company, between the Mediterranean and Red Sea, for the works of construction and maintenance, amounts to 39¾ square miles, and about 37 square miles were required for the construction of the fresh water canal. The former area was apportioned by the Egyptian Convention of February, 1866, in the following manner:

	ACRES.
Port Said	1062.50
From Port Said to El Ferdane	5831.50
Raz-el-Ech	37.00
Kantara	158.00
From El Ferdane to Lake Timsah	4003.00
Ismailia, on Lake Timsah	2854.00
From Lake Timsah to the Bitter Lakes	4200.75
Across the Bitter Lakes	3508.85
From the Bitter Lakes to the Lagunes of Suez	1927.40
Across the Lagunes of Suez	889.50
Port of Suez	889.50

By the original concession the powers of the Canal Company were not restricted to this area; but they were definitely settled by Napoleon in April, 1864, when, in his character of Imperial referee, he adjusted the difficulties which had arisen between the Egyptian Government and the Company. By that decree he awarded an indemnity of £3,360,000 to be gradually paid by the Egyptian Government in instalments, commencing on the 1st of November, 1864, and expiring November 1st, 1879; the sum of £1,520,000 was to be paid as compensation for the substitution of European workmen for Egyptian laborers, and the increased dredging plant; £1,200,000 for the abandonment of certain land rights granted under the concession of 1856, in repayment for the sums expended and works done upon the fresh-water canal; £400,000 and £240,000 as payments in full of all rights to duties levied upon the fresh-water canal.

According to the published accounts of the Company, the total amount raised for the works since the opening of the subscription in France in November, 1858, has been £18,066,265, and the total expenses, including works, material, and ınt, the purchase of certain lands, the financial, engineering, and general administration, has amounted to £16,174,933, leaving a balance in hand, between the actual outlay and the subscribed capital, of £1,891,332—a sum chiefly made up by £1,189,781, the concession of the Egyptian Government, and £680,000 of cash in hand at Alexandria and Paris.

The details of the gross realized capital may be briefly collected as follows:

Shareholders' capital	£8,000,000
Sale of bonds	3,999,996
Egyptian Convention	1,189,781
Imperial arbitration	3,360,000
Rates of exchange	258,852
Various receipts realized by the Comp'y	1,257,636
	£18,066,265

The summary of the expenditure account stands thus:

General expenses of preliminary arrangements, survey, etc., from 1854 to 1859	£3,165,705
General expenses of administration and negotiation between France and Egypt	678,449
Sanitary service, 1868, 1869	24,282
Telegraph service, 1868, 1869	6,800
Transport service, boats, rolling stock, buildings, etc	324,887
Payments to contractors for materials	688.557
Dredging machines and heavy plant	1,363,848
Workshops	168,830
Works of construction, canals and ports	8,706,866
Miscellaneous	278,499
Expenses of various branches of the Company's management	768,210
	£16,174.933

So that the actual amount expended upon the canal has been £161,749.34 per mile. This amount, of course, represents the total outlay, from which have to be deducted the sums to be realized by the sale of plant, the Egyptian concession, the indemnity award, and, to arrive at the actual cost of construction, the expenses of management, a total of £9,394,938 to be deducted from the £16,174,934, leaving £6,779,996 as the total cost of construction up to the end of June last, the balance in hand being then, as we have seen, £1,891,332; and, assuming that this balance was found sufficient to complete the works, the actual cost per mile of the

canal proper will have been £8,671,328, exclusive of administration, etc.

Now that the long and tedious work is finished, it is but natural that the acclamations which greet the successful severance of the Isthmus should occupy the universal breath, and that admiration of the work should absorb all public thought. But a few weeks, however, and the Suez Canal will be no longer universally regarded as a modern wonder of the world, but as a commercial and maritime convenience, and what is now gazed upon as marvellous will soon become common-place. Then all the doubts which have been current, and strengthened by the unfortunate grounding of vessels on the inauguration day, will have been scattered or confirmed; we have M. de Lesseps' assurance that all the fears occasioned by those *contretemps* are groundless; but a short experience of the practical working of the canal will refute or establish theories, and it will be interesting to watch whether the sandbanks, as prophesied by alarmists, will stop the navigation; if the harbor of Port Said will silt up, and the canal become choked, or its banks destroyed. And the time that is needed to test the engineering success of the work will also prove sufficient to establish its commercial prosperity or failure. The competition and advancement of trade seem alike to forbid the latter; and not the canal alone, but the Mediterranean ports also, will share the advantages of the trade it has diverted. The following table, compiled by M. de Lesseps, shows the saving of distances which will be effected by the adoption of the Isthmus route, Bombay being taken as the converging point:

Distances.

European and American Ports.	By the Cape.	By the Canal.	Saving Effected.
	miles.	miles.	miles.
Constantinople	14,760	4,350	10,410
Malta...... ..	14,130	4,990	9,140
Trieste	14,420	5,660	8,760
Marseilles	13,675	5,745	7,930
Cadiz.........	12,584	5,384	7,200
Lisbon	12.950	6,050	6,900
Bordeaux	13.670	6,770	6,900
Havre	14,030	6,830	7,200
London.......	14,400	7.500	6,900
Liverpool	14,280	7,380	6,900
Amsterdam ...	14,400	7,500	8,900
St. Petersburg.	15,850	8,950	6.900
New York.....	15.000	9,100	5,900
New Orleans ..	15,600	9,000	6,600

The average distance being reduced one-half *via* the now route.

Even before its completion the Suez Canal was pressed into the service of transporting goods to the utmost of its capacity, and up to the 30th of June last, £136,865 has been realized by tolls. Already, for six years the harbor of Port Said had been a resort for ships. In 1863, 295 ships, collectively of 48,759 tons, had called there. From the 1st of June, 1867, to the 15th of April, 1868, 1,000 vessels, representing 232,000 tons, had entered Port Said—a number which increased during the following year to 1,362 ships, collectively of 637,440 tons. At this present time Port Said forms a depot for no less than seven steam navigation companies—the Messageries Impériales, the Society-General of Steam Transport, the Marc Fraissinet Company of Marseilles, the Bazin Company, the Russian Company of Navigation and Commerce, a Spanish Steamship Company, the Austrian Lloyds; and an American Company is about to be established with a capital of £6,000,000 with the Mediterranean ports as depots, and trading thence to India and China; while we are of course building vessels specially designed for the new route.

With so much activity, and with hope of so vast a diversion of trade towards the canal, the prospects of the Mediterranean ports are especially flourishing. Marseilles of course will reap the greatest advantage, but all the other towns upon the coast will profit by the benefit of a newly-created trade, or will awake to win back the positions they once held.

The French are making arrangements in good time for observing the transits of Venus, which will take place in the years 1874 and 1882. The event is one of considerable interest and value to scientific men, and it is therefore desirable that it should be viewed from those parts of the earth's surface where it can be best observed. The stations fixed upon for 1874, are Oahu (one of the Sandwich Islands), Kerguelen Island (in the Indian Ocean), Rodriguez (a dependency of the Mauritius), Auckland (New Zealand), and Alexandria.

The directors of the Edinburgh School of Arts have agreed to allow female students to attend its lectures and classes.

RESEARCHES UPON THE STRENGTH OF MATERIALS EMPLOYED IN MODERN SYSTEMS OF BUILDING.

From "The Builder."

We are in receipt of the second and concluding volume of Mr. Bindon Stoney's work on strains in girders and similar structures.*

The work, in its complete form, appears likely to prove so important a contribution towards the elucidation of the science and practice of construction, that we are inclined to consider that the present volume, from the elements of which it treats, puts forward claims to somewhat fuller notice.

Although so long an interval may be regarded by some to have elapsed before the appearance of the concluding portion of the work, when the wide range of authorities to which the author has had occasion to make reference is noted, and the nature of the inquiries incident to such a work is borne in mind, it will no doubt be admitted that time would be necessarily occupied in the production of such a volume as that which is now before us.

It appears at an opportune moment, as a want has long been asserting itself, no less on the part of the general public than in professional circles, with reference to the comparative safety and durability, as well as cost, of modern engineering and architectural erections.

More particularly may this, perhaps, be said to be the case in regard to compound structures in which iron and other materials may have been extensively employed.

A theory has sprung up of late years which has been by many considered favorable to the application of iron to building purposes largely in conjunction with the ordinary practices of architecture. Since the introduction of this system, however, the theory of construction itself would appear to have become so widened by successive changes in the manufacture and preparation of building materials, more especially of lately added elements, that former investigations into the strength and properties of materials, have in some instances become more or less valueless and inapplicable. Unlike a somewhat similar treatise to that which is now under consideration, which was issued by Mr. Clark, and founded upon the construction of the Conway and Britannia tubular bridges, the conclusions which have been arrived at by the author of the present volumes are not alone based upon such features as might have been observable during the erection of any particular undertaking, but in addition embrace the opinions of many well-known authorities who have treated of some of the questions which are involved. The treatise upon the Anglesea and Carnarvon Bridges has long been regarded as an authority of rank, owing to the circumstance that many of the assertions which it embodies could be referred to actual experiments which were necessitated in carrying out the undertakings of which the work treats. The value of Mr. Stoney's work, independently considered, may be inferred, when it is remembered that in a single span of 460 ft. of the Tubular Girder Bridge, between Holyhead and Anglesea, no less a quantity than 3,000 tons of material is employed, while in other structures which serve a like purpose, the desired objects have been accomplished with less. Notably we would refer to the late Mr. Roebling's bridge over the Niagara Falls, in America—a structure which is, as well known, used for purposes of locomotive passenger and goods traffic, and yet comprises within a single span of 820 ft. only 1,000 tons of materials, and of this quantity more than one half is timber. The scope which, by such a contrast alone, would seem to be afforded for a more economical adaptation of material than that which obtains in English practice, might be considered to justify the researches into which Mr. Stoney has been led in these volumes, and we would have been far more displeased to have observed a reference to the comparative cost, style, and weight of such undertakings as executed in England and elsewhere, notwithstanding the prejudicial

* The Theory of Strains in Girders and similar Structures; with Observations on the Application of Theory to Practice, and Tables of the Strength and other Properties of Materials. By Bindon B. Stoney, B. A., Member of the Institution of Civil Engineers, and Engineer to the Dublin Port and Docks Board. In 2 Volumes, with Illustrations. London: Longmans, Greene & Co. 1869.

reflections to which such an inquiry might be calculated to give rise.

The question of the weight of materials demanded in the erection of bridges was, we believe, first sought to be experimentally realized in this country by Mr. Peter Barlow, whose standard investigations upon the strength of materials are frequently referred to in the present volumes. Although, contrary to the predictions of the moment, considerable success has attended the erection of the Niagara Railway Suspension Bridge, the system upon which it is constructed would not appear to have largely recommended itself for adoption. Numerous costly railway bridges have recently been erected over the river Thames, and in some instances the question of level has, at great additional cost, been seen to have been subordinated to the requirements of an arch structure. A more extensive application of the Niagara Bridge system has been lately employed in the designs of a grand bridge over one of the American rivers, and we believe that it has long been an object, on the part of Mr. Peter Barlow, to introduce a somewhat similar class of suspension bridge into the domain of engineering science in this country. It is well known that the present Lambeth Bridge embodies a most important series of investigations as to the cost and stability of bridge accomodation, and that Mr. Barlow made a special journeyto inspect the Niagara structure before this experiment was attempted. The longitudinal stiffening of the Lambeth Bridge is of iron, while in Mr. Roebling's design it is of wood. The question as to the desired rigidity in such structures mainly resolves itself into the dependence which may be placed upon the nature of the materials to be employed. Prior to the application of iron in the form of wire cables in suspension structures, it is well known that English engineers regarded with much diffidence the continuity of certain qualities in iron throughout great lengths, either in the form of girders, suspension links, or laminated bands. This doubt yet largely prevails, and some important evidence is adduced in reference to these points by Mr. Stoney, which is likely to engage considerable attention in the professions of engineering and architecture.

We are led to infer that the author is in accord in a certain measure with Mr. Barlow as to the magnitude of practicable spans upon the suspension principle, and that this object would be chiefly likely to be attained where the inherent defects attending the application of iron in ordinary forms may be avoided. So far, up to the present moment, the economical appliance of iron in the erection of bridges of large span would appear to be discovered in cases where that material has been employed in the form of continuous twisted wire ropes. In view of the future erection of any large railway bridge, say, for instance, over the Mersey, uniting Liverpool and Birkenhead, a project which has been long contemplated; or, in the event of the necessity arising for the maintenance of the connection between Holyhead and Anglesea, should the existing means fail, the practicability of the suspension system as seen to be successfully carried out in America, will necessarily claim further attention and research.

Mr. Stoney's reference to the experiments of Mr. Kirkaldy, which are given in a valuable tabulated form in the body of the work, are in no way calculated to reassure us as to the advantages which would be likely to attend a too unguarded employment of iron and cognate materials in architecture. It has been demonstrated that regard must be paid to architectural requirements in cases where iron may be proposed to be employed as an auxiliary material, and many results tend to prove that in this respect the tentative science of engineering must be held subordinate to the better founded and established laws of architecture.

Mr. Stoney observes that when an imperfectly elastic material has received a permanent set from the application of any weight, which is subsequently removed, the material becomes more perfectly elastic than before, within the range of strain which first produced the set, and its alteration of length per unit of strain is less than at first. For practical purposes the author asserts that the limits of elasticity in wrought-iron does not exceed 12 tons per square inch; and though higher strains than this may not in the least diminish its ultimate strength, yet they will take the stretch out of it, and this may render iron which was originally tough and ductile so hard and brittle as to be seriously injured for many purposes. It is, in our opinion, to the injudicious tests to which iron is

occasionally subjected, that many cases of rupture may be attributed in that material, and possibly many instances of disastrous boiler explosion. The extreme facility with which the tensile strain and compressive resistance of iron may be regulated has almost rendered the employment of that material at length dangerous, especially in conjunction with materials of dissimilar properties.

Iron may be made to pass through so many grades of deterioration in its manufacture without readily indicating the processes to which it may have been subjected without actual strain or fracture, that the tendency of home and foreign competition, coupled with the facilities to which we have referred, has resulted in bringing the production of that article in England in some directions to a discreditable level. It would appear that the tensile properties of iron may be retained over a wider range of cheap contamination than some of its other properties, and many of the qualities of iron now usefully employed in building are imported from abroad.

We notice with interest that in connection with the theory of strains in girders and similar structures the imperfections which are most commonly to be met with in the materials which are adverted to, are viewed with that importance which this branch of the subject deserves. There could not, perhaps it may be said, be found in any publication extant a more masterly exposition of the general properties of iron than is to be met with in this volume. No review of a work of this kind could probably do full justice to its contents, for being mainly intended for the instruction of engineering students, and for guidance in the varied elements of constructive science, it would be attended with difficulty to single out for especial remark any particular branch of which it treats. We do not remember, however, in any similar work which has come under our notice, to have observed the question of connections in iron so treated of as in some portions of the later volume, more particularly under the heading of "Appliances for Connecting Iron Work," pages 351 to 370. A perusal of the first 265 pages of vol. ii. would well repay the attention of architects and builders, being composed more particularly of a treatise on compressive resistance in bodies of brick-work, stone, iron, and various classes of cements, as well as including the action of cements and builders' materials under tensile and lateral strains. This feature of the work, in view of the recent incident at the Holborn Valley Viaduct, is entitled to especial attention.

Quoting some experiments of Mr. Clark, in relation to the action of stone under compression, the author says that in the instance which he refers to, "the sandstones gave way very suddenly, and without any previous cracking or warning. After fracture, the upper portion generally retained the form of an inverted square pyramid, very symmetrical, the sides bulging away in pieces all round. The limestone formed perpendicular cracks and splinters a considerable time before they crushed."

It will be borne in mind by many that this description represents very nearly the order in which the fractures in the Farringdon Street columns would seem to have been generated. We hope, however, these are not so extensive in the mass as might be inferred from the external appearance of the columns. Continuing from this portion of the work, Mr. Rennie observes: "It is a curious fact, in the rupture of amorphous stones, that pyramids are formed, having for their base the upper side of the cube next the lever, the action of which displaces the sides of the cube precisely as if a wedge had operated between."

The features which have presented themselves in the visible lines of fracture upon the polished facets of the Holborn Viaduct column, appear so to approximate to what might have been anticipated from the experiments which are described in this portion of Mr. Stoney's work on the theory of strains, that we view the occurrence with a regret which no assurance with which we have yet been inspired has diminished to the extent that could be wished.

The importance of such a treatise as that which Mr. Stoney has at length produced, in the hands of the pupils of modern engineering and architectural establishments, cannot well be overrated.

In concluding the observations which we have been led to make upon the perusal of the work, we would note the singular lucidity of the arrangement of the letter-press, and the novelty of the illustrations which is displayed. As an ex-

ample of the clearness and simplicity for immediate reference with which works of a similar character may be contrived, it may claim to possess several features well worthy of imitation.

Mr. Stoney's work lends a ready key to the more abstruse elements and problems of constructive science; and it is sufficient to bear in mind the length of time over which the author's labors have extended in its production, to reach the conclusion that the work may have been written with other objects than those of pecuniary gain or contemporary praise.

It cannot fail to be regarded as a valuable accession to the literature of applied arts and sciences, and in its more especial direction should take a foremost rank.

SOMETHING ABOUT BELLS.

From "The Century."

The largest bell in the world is in Moscow—the City of Bells. It was cast by order of the Empress Anne, in 1653; is 21 ft. 4½ in. in height, 22 ft. 5½ in. in diameter where the clapper strikes, and is believed to weigh from 360,000 to 440,000 lbs. Historians are in doubt whether this giant among bells was ever hung. Dr. Clark, who saw it about the year 1801, says, in his "Travels," "The Russians might as well have attempted to suspend a line-of-battle ship with all its stores and guns." Bayard Taylor, on the other hand, maintains that it was both hung and rung, "it being struck by the clapper," as Korb says in his diary, "fifty men pulling upon it, one half upon each side."

In 1837, the Czar Nicholas caused it to be disinterred from its bed of sand, where it is supposed it was lodged during the conflagration of 1737, and placed it on the granite pedestal where it now rests. It was then consecrated as a chapel, the entrance to the interior being through a large fracture near the mouth, the cause of which is also a subject of controversy.

It is recorded that at the casting of this bell, nobles were present from all parts of Europe, who vied with each other in the value of the gold and silver plate, jewelry, and other votive offerings which they cast into the furnace. It is doubtless owing to this practice, which prevailed in olden times, that the existing notion is derived that ancient bells are of better material than the modern ones, on account of the silver in their composition. It may be added, however, that the idea is incorrect, since recent experiments have shown that its introduction causes a positive deterioration of the resonant quality of bell metal. Whoever has been in Russia recalls as chief among his memories the sounds of the great bells which form a part of religious worship, and are regarded by the Russians with superstitious veneration. In Moscow alone there are five thousand, and when they unite on festive occasions in one mighty chime, the effect, especially at a distance, is said to be majestically grand.

There is now suspended in the tower of St. Ivan, at Moscow, a bell which weighs 144,000 lbs., and the diameter of which is 13 ft. It is said that when it sounds, which is but once a year, "a deep, hollow murmur vibrates all over Moscow, like the fullest notes of a vast organ or the rolling of distant thunder."

The bell of Notre Dame Cathedral, at Paris, cast in 1680, weighs 30,000 lbs.; that of St. Peter's, at Rome, weighs 17,000 lbs.; that of Notre Dame Cathedral, Montreal—the largest in America—29,000 lbs.; and that of the Parliament House, in London, 30,000 lbs. When it is remembered that the largest bells heard in our American cities rarely weigh more than 3,000 or 4,000 lbs., some idea may had of the volume of tone which belongs to the monster bells above described.

The Chinese have likewise produced bells of colossal size, one of which, at Pekin, weighs 120,000 lbs., but the tone of their bells is said to be discordant and "panny" like that of their gongs."

The most remarkable fact in connection with the mortality of Bombay is that more than one-half of the total casualties are casued by zymotic diseases of the miasmatic order—that is to say, are consequent on defective drainage, impure water, absence of ventilation, and the unclean habits of the community.

UNDER THE THAMES.

From "The Building News."

In March of the year 1843, the first passage under the Thames was opened to the public by the celebrated engineer, Isambard Brunel; in a few weeks a second sub-way was opened by Mr. Barlow. Separated by an interval of 26 years, passing under the same river at points not widely apart, it may be instructive to "compare notes" on the two.

"*The* Thames Tunnel" has for long been one of the wonders of childhood, a leading attraction in pictorial exhibitions, and from its subterranean depths many a toy has been carried into far-off country villages as a memento of a visit to the great metropolis. These associations have thrown around Brunel's great work a sort of halo which Mr. Barlow's tube will never achieve. Our purpose, however, lies with the constructive peculiarities of the two kindred, yet unlike, works. It must not be supposed that no attempt had been made, prior to the time of Brunel, to pass the Thames by a tunnel; on the contrary, we find that a company called the Thames Archway Company commenced a tunnel so far back as 1804, and did, indeed, penetrate the bed of the river for a distance of 1,040 feet. Unfortunately, a very high tide put a stop to their labors, as a violent inrush of water filled the tunnel. After some attempts to raise capital to pump out the water, the whole scheme was abandoned. This tunnel was to have led from Rotherhithe to Limehouse. Even so far back as 1799, a tunnel was talked of between Tilbury and Gravesend.

The following are the salient points in the history of Brunnel's tunnel. The plans were completed in 1823, and the works commenced in 1824. The great mistake made in this first tunnel was in carrying the heading too near to the water of the river; in fact, sometimes not more than 4 ft. intervened between the tunnel and the water. Great, almost insurmountable difficulties were thus encountered. During the progress of the work a stoppage of seven years occurred through an irruption of the river. After incessant care, and the exercise of great engineering skill, Brunel completed his great work in 1843. Thus 19 years elapsed between the commencement and finish of this work, which even now stands unrivalled in the solidity of its construction. Deducting the 7 years during which the works were suspended, it will be seen that 12 were really spent in its completion. As its construction was difficult, so was it also costly, the total expenditure being about £450,000. As is well known, the sub-way which Brunel thus made has been purchased for purposes of metropolitan railway extension. Ere long two lines of rails will traverse its massive arches. Thus, in this final adoption of his great work, has Brunel the Elder been proved to have been right, but before his time; just as his yet more famous son has triumphed over those who scoffed at the "Great Eastern" as a useless monster, little dreaming of the work she was to do in joining far distant lands together by magic electric bonds of union. Turning now from the massive elliptical brick-work of Brunel, with its two 14 ft. archways passing, as it were, along the foci of its length, let us look at the no less wonderful work of Mr. Barlow. As Brunel's work was marvellous for its vast solidity and the many difficulties overcome in its construction, so is Mr. Barlow's subway wonderful for its cheapness and the ease and rapidity with which it has been executed. On the 16th of February, 1824, Brunel commenced his tunnel, and finished it in March, 1843. Just 45 years later, on the 16th of February, 1869, was the present sub-way started, and it will be opened in November, thus taking nine months to complete. The estimate for its construction was £16,000, and the cost will, in fact, most probably be under this sum. Of course, in comparing the cost of this present work with that of Brunel's, the very great difference in magnitude must be borne in mind. The dimensions of Mr. Barlow's tube are as follows: The diameter of the tube is 7 ft., and its total length will be 1,320 ft., of which 1,110 are finished; its material is cast-iron. This cast-iron is disposed in segments, each reaching 18 inches along the tunnel, and nearly $\frac{1}{3}$ round it, and weighing about 4 cwt. each. At the top a key is inserted to tighten the segments into their places.

These keys weigh about 1 cwt. each. The joints are made with strips of white pine between the longitudinal flanges, and with tow in the circular ones. The tunnel is cut through the London clay at such a depth that at no spot does the river water come within 22 ft. of the tube. That there should any injury arise to the tube from the action of water is very unlikely, as not only is the clay so free from water that every drop required for the work has to be sent down the shaft on Tower-hill, but a coating of lias cement is being forced in around the tube by pumping. To admit of this being done, a space of 1 in. is left all round the tube by cutting the heading through the clay that much larger than the tube itself. One very remarkable fact in connection with this tunnel is the great distinctness with which sounds reach it from the river overhead. The passage of steamers up and down the river is distinctly audible in the sound of the paddles and screws; nay, sometime back, Mr. Barlow was fetched in a great hurry to see what was the matter, because a sound as of rushing water was plainly heard. On examination this sound, which had so alarmed those working in the tunnel, was found to be caused by a large steamer in the river blowing off her spare steam. Recently a steamboat exploded near the Tower Wharf, and, strange though it may seem, not only was the explosion audible, but its effects could be plainly felt in every part of the tunnel. At the present time it is rather sultry at the end of the tunnel near the shield, as all the air has to be driven in by a fan in the shaft, and a good deal of warmth is naturally produced by the men at work and the candles needed for their use. So soon, however, as air is reached at the Tooly street side, all will be cool enough. On the completion of the tube, rails of 2 ft. 6 in. gauge will be laid in it, and upon these rails omnibuses of iron will be run. These omnibuses will be 10 ft. 6 in. long, 5 ft. 3 in. wide, and 5 ft. 11 in. high. At the bottom of the shaft at each side of the river will be provided ropes, driven by stationary engines. These ropes are to give the buses a start of about a hundred feet down the incline. After this impetus the vehicle will descend the rest of the incline and ascend the opposite one without further application of power to it, except from the effects of gravity in the first half of its transit. Up and down the shafts the passengers are to be taken by means of lifts. Mr. Barlow estimates that not quite three minutes will be requisite for each transit, including the raising and lowering of the lifts. Allowing, therefore, 14 persons to each journey, and 16 hours to each working day, upwards of 4,400 passengers per day can be carried. If requisite, two omnibuses can be joined together, or one of double or treble capacity used, so that a very large traffic can be accommodated. There seems to be little doubt, therefore, that the tunnel will turn out a very good thing for the shareholders, paying them very large dividends. The continuous and heavy traffic over the many bridges across the Thames has reached dimensions by no means convenient to those who have to pass them. Notably the traffic over London Bridge has so overtaxed that venerable viaduct as to render it highly dangerous to her Majesty's lieges, and to call forth the proposition to carry out excrescent footways on cantilevers and brackets, to the everlasting disfigurement of the noble pile of granite.

On the success or non-success of Mr. Barlow's under-river omnibuses turns a very important question. The great test will be in the return that the shareholders will get for their money. If their dividends are large, two things will be proved—namely, that tunnels beneath rivers can be made at a sufficiently small cost to pay, and also that they supply—in crowded localities, where navigation claims the stream—a public want. To prove that the public needs them, and that they can be reasonably constructed, so far as cost goes, means to stimulate their construction in many localities besides the metropolis. We may expect during the next year or two to hear of a good many schemes for going *under*, rather than *over*, rivers. Naturally enough, some of these tunnels will be made in places where a sufficient traffic cannot be got to make them remunerative; but, on the average, the public will benefit more than it will lose. To argue in the present day in favor of good means of communication would be like stepping back half a century to commence the race of life; yet it is by no means a superfluous observation to say that our facilities for easy and swift transit are by no means what they might be, and what we trust they shortly will be. To all of

as time is generally the equivalent of money, and people are often more fatigued in going to and returning from some business than by the work itself. Never before did such a need of cheap, quick transit for our working classes, the busy bees of our great hives, exist. Mr. Barlow and others, therefore, who seek to supply the means, deserve every encouragement.—*Palmam qui meruit ferat.*

MODES OF MURAL DECORATIONS.

From "The Builder."

A technical work of much value has just appeared from the pen of Mr. W. Cave Thomas, on the subject of mural decorations, evidently the result of much thought and labor.*

One of the author's leading theories is, that art should endeavor to depict or model perfect humanity; and that education should endeavor to make this ideal, ultimately, a living fact. He says at the onset, pertinently, that he cannot understand why poets and painters should wish to infer that their "inspiration" is independent of rules and science; for order being Heaven's first law, it must be certain that no success can be achieved that is not the result of, either consciously or unconsciously, working in accordance with scientific principles. Thus pronouncing himself in the ranks of order and moderation, as he has done before in other works from his pen, Mr. Thomas proceeds to state the antiquity of mural painting as the earliest form of pictorial art, and its value as a memorial of national existence, and of the aspirations of that existence. Michael Angelo spoke of easel painting as an occupation fit for women, compared with mural painting; and Mr. Thomas, like ourselves, follows in his wake as far as the highest appreciation of the last-mentioned branch takes him.

He treats of fresco painting first. Odd confusion has long existed as to the meaning of the word, fresco; for people even now constantly speak of all pictorial mural decorations as frescoes; but, as most of our readers must be aware, the term properly applies only to those wall paintings that are executed by means of a particular process. Encaustic paintings, oil paintings, and water-glass paintings, are easily applied to walls; but that application does not constitute them frescoes. Although we are not going to give the details of the processes described by Mr. Thomas, which should be studied from his work, we may point out that frescoes are paintings made with colors simply mixed with water, upon fresh wet mortar. The necessity for newness in the mortar is so important, that only sufficient is placed upon the wall to enable the painter to execute the piece he has undertaken for one day's work. On the following morning, or whenever he resumes his task, another piece of wall is newly plastered, to admit of his operations. But it is within the limits we have set out for ourselves, to quote the nature of the preparations a wall should receive that is intended for frescoes. The Italian masters preferred this vehicle to any other, if we may consider their most frequent use of it a sign of preference; but, with the exception of the frescoes in the summer-house at Buckingham Palace, and those in the Houses of Parliament, there are scarcely a dozen examples of the process to be counted in this kingdom.

Mr. Thomas states that a brick wall, a brick or brick and a half in thickness, well dried, and of equal hardness, is the best kind of wall for the purpose. The use of laths is sometimes resorted to for special circumstances, but never when a dry brick wall is available. Outer walls, having a liability to damp, he would have lined with brick; and he records the suggestion of a detached inner wall, bound here and there to the outer one, without, however, quoting any actual experiment of this plan. Speaking now, out of our own experience, we should hesitate to adopt this last mode, having known the places where the junction is made between the two walls to be so many means of conducting the outer damp to the inner surface and spreading it in patches. Mr. Thomas objects to bat-

* Mural or Monumental Decoration; its Aims and Methods. Comprising Fresco, Encaustic, Water-glass, Mosaic, and Oil Painting. By W. Cave Thomas. London: Winsor and Newton, 38 Rathbone place.

tens and laths on account of their perishable qualities; but he mentions that many of the fine Italian ceilings are on lath and in good condition. He thus describes their construction:

"Most vaulted ceilings, in what is termed the *piano nobile*, or principal floor of every palace, are constructed of wood. The lathing in this case is not attached to single thin pieces of timber, cut to the shape of the ceiling, but to a strong grating; in some cases the ribs and transverse pieces of this grating are 4 in. thick each way. The lathing in Italy is a very peculiar process. The material is the reed, which is cultivated so extensively in that country, and used in so many ways. It grows to the length of about 18 ft., and is rather more than $1\frac{1}{4}$ in. in diameter at the base. When these reeds are used for lathing, they are split, and not being strong enough for the purpose, in this state, they are wattled upon the grating. The result of this somewhat complicated contrivance is a framework of great strength."

Assuming, however, that the surface intended for a fresco is a brick wall, the face of the bricks should be chipped, so as to enable them the better to hold the rough coat of mortar. This last requires to be applied with care, for if it be uneven, there will be patches of dust lying on every projection, and if the inequalities are filled up in the after coat, there will be cracks occurring between the thick and thin places. The tendency dust has to adhere even to a strictly perpendicular surface, has been taken into account, and a suggestion made that walls intended for frescoes should incline slightly forwards. The rough coat should be left to harden thoroughly before the next process is attempted. If the lime used in the mortar be fresh, two or three years will be required for it to attain the necessary condition. The quality of the lime is a matter, too, of the greatest moment in the next stage. The limestone used by the cinquecento artists was travertine, which is almost a pure carbonate of lime. Mr. Thomas gives the proportions as—

Carbonate of lime	99.4
Alumina with a trace of oxide of iron	.6
	100.0

While the lime used by the Genoese, which has resisted the effect of sea air for centuries, in a remarkable manner, yields:

Carbonate of lime	63
Carbonate of magnesia	36
Earthy matter, oxide of iron, and bituminous matter	1
	100

Nothing remains but to attend to the causticity of the lime, for if used too soon after being slaked, it blisters, and pictures executed without this proper precaution have flaked off, leaving, in the white patches exposed, all the effects of a snow storm. Some authorities aver that it should be kept for several years; some for three; some only for a few months. The German painter, Cornelius, prepared his lime for the frescoes in the Ludwig Kirche eight years before he used it; and an Italian writer of the sixteenth century, Leon Battista Alberti, speaks of a honey-like consistency gained by lime that had lain by for 500 years. But Mr. Thomas shows all that is requisite is that it should regain its maximum of carbonic acid. He adds that some degree of causticity is necessary to give the adhesive firmness required for induration; and is very precise in his details of preparation for both the rough cast and the upper coat, or *intonaco*, destined to receive the colors of the fresco. The implements, the colors, and the mode of operation, from the time the painter applies his tracing to the fresh mortar, till his day's work is glowing, finished, under his hand, are described minutely. No painter can need further instruction.

An important part of Mr. Thomas's book includes an exposition of the water-glass process, first discovered, or invented, at Munich, which many think may prove superior to all other modes of decoration. The information he publishes concerning it is a reprint, he has been permitted to give, of the pamphlet by Professor Fuchs, first translated from the German, printed and privately circulated, by command of the late Prince Consort. And this is supplemented by the report of Mr. Maclise on the process, and the correspondence that took place with German artists on the subject preparatory to its use in the Houses of Parliament. To those of our readers who are not acquainted with the nature of this composition, we may explain (though it has been before fully set forth in our pages), that there are four kinds of it—potash water-glass, soda water-glass, double water-glass, and fixing water-glass. The first is a mixture of fifteen parts of pul-

verized quartz, ten of well-pulverized potash, and one of powdered charcoal, mixed and exposed to a strong heat in a melting-pot till melted, when it is taken out, broken up, pulverized, and dissolved in about five parts of boiling water in an iron vessel; where it must be stirred and the water replaced as it evaporates, for three or four hours. This mixture, which is prepared with a care duly inculcated, when applied to surfaces has the property of rendering them compact, hard, and solid. Like glue, the Professor says, it may be employed for imparting solidity and greater cohesion to loose masses, for filling up cracks, and similar purposes. The other water-glasses have such differences in their ingredients as their names suggest, all of which are faithfully given and their effects described; and it is yet a matter of conjecture which will answer the purpose best. The chief purpose for which they are applicable and prized, is that of mural painting. They cause the colors to adhere well; and they give great durability, if not indestructibility, to them; and it is expected that when applied to existing frescoes they will prevent their further decay. But it is as a medium for new paintings that water-glass has raised the most sanguine expectations. As in frescoes, a coating of mortar cement is first applied to a wall intended to be covered with a painting, but before the *intonaco* is thought of this first coat has to be saturated with water-glass several times. When dry, the second coat is proceeded with, and in its turn impregnated with the same binding and cementing material. The German artists, Baron Kaulbach and M. Echter, who have done most for perfecting the application, find that the colors must be ground with pure water and the wall kept moist, whilst the artist is engaged upon it, by means of syringing it with water. Professor Fuchs applied water-glass to a stove-tile with some success; and the director of the telegraph-office at Munich has applied it to iron. A suggestion is thrown out, too, that plates of lithographic limestone might be used as a ground for water-glass paintings, which stone plates could be let into walls so as to appear to be part of them, and yet could be removed if necessary. In his list of mural decorations, Mr. Thomas mentions one painting executed with this material besides those in the Houses of Parliament—a procession subject, by Mr. Gambier Parry, at Coombe Abbey.

Touching mosaic, he speaks of the history of its revival by the Murano glass-blower, Lorenzo Radi, however, and its recognition by Dr. Salviati, of Venice. Its application in this country in the Wolsey Chapel, Albert Memorial, and Westminster Abbey, after designs by Mr. Clayton, is well known. But although France had a school for mosaic artists in Paris thirty or forty years ago, and Russia and Venice have now their rival manufactories, and Rome still encourages the art within the privileged precincts of the Vatican, there is little effort made in England out of South Kensington to further the use of this style of decoration. Two or three English writers have kept the subject before the public, and urged its advantages. Furthermore, Mr. Cole has a strong desire to create a taste for this kind of decoration, and Messrs Minton, Maw, Simpson, Rust, and others, produce ceramic tesseræ; hence it is probable that in a future edition Mr. Thomas may have to record that the art has taken root in this country. It is best applied in lofty spaces, such as vaults and domes of public buildings, where the limitations of its powers are least apparent; and needs caution and moderation in endeavoring to avoid both the meagreness of the earliest efforts and the redundance of the latest. It has but little of our author's sympathy, and he makes no effort to obtain for English art the honor of having made Abbot Ware's opus Alexandrinum in Westminster Abbey, though the substitution of Purbeck for cippolino, the usual groundwork, has led others to believe it was executed in this country.

After reading Mr. Thomas's book, we think of the great masters of old, not as the portraits of many of them show them, idle, clad in velvet and furs, with plumes in their caps; but in their equally pictorial blouses, pied with daubs of color, moving about on scaffolding, or ascending ladders, with their clever hands gritty, their speaking faces full of wonder, anxiety, and conjecture as to the result of the processes they are employing; and we feel that some of this uncertainty will be diminished for future painters by the care with which the various processes are described in it, and the fulness with which the result of many experiments are stated.

THE CHATELIER BRAKE.

Abstract from "The Engineer" and "Mechanics' Magazine."

The name of M. Le Chatelier has long been familiar to the engineering profession in connection with investigations bearing upon the economic working of the locomotive engine and other important matters. He now comes before us as the practical exponent of a principle which has received attention for some years past at the hands of several engineers. This is no less than enabling the driver of a locomotive, when reversing steam, to utilize the work done during the inverted action of the engine for regulating and checking the speed of trains. In other words, M. Le Chatelier has perfected a steam brake, and, although it comes to us as a novelty, it has already been applied to nearly 3,000 locomotives on the continent. With regard to the attempts which have from time to time been made to effect this object, we may first mention that in France M. Beugniot and in Austria M. Zeh have experimented with closed exhaust nozzles; the one so as to cause a vacuum behind the piston, the other to establish a pressure behind the piston, and thus avoid drawing in the heated gases of combustion from the smoke-box. Early in 1865 Mr. De Bergue experimented with a system of brake by compressed air, so arranged as to prevent the introduction of the fixed gases into the boiler. This system gave satisfactory results for short runs of two or three minutes, but did not answer when the action was prolonged. In July, 1865, M. Le Chatelier directed experiments to be made on this important subject on an entirely new principle, and his ideas have been put in practice with complete success both in France, Spain, and Germany.

In ordinary locomotive engines, when the valve gear is reversed while running forwards, for obtaining in an emergency the retarding effect of the full boiler pressure opposing the motion of the pistons, the reversed working cannot be continued longer than a few minutes without serious injury, owing to the heating of the cylinders and the cutting of the rubbing surface from want of lubrication; the cylinders act as pumps in the reversed working, drawing in the heated gases from the smoke-box and forcing them into the boiler. The object of the present plan is to enable locomotives, in taking trains down inclines, to be worked continuously for any length of time with the valve gear reversed, so as to obtain the advantage of the counter-pressure steam as a retarding power, instead of the train brakes, without involving the objections hitherto preventing the use of continuous reversed working. In the regular working of locomotives, not reversed, the piston in its forward stroke is propelled by the full pressure of steam from the boiler, until the steam is cut off by the slide-valve, after which the propelling power is continued through the remainder of the stroke by the steam expanding in the cylinder. But in the reversed working the distribution of steam is effected by the slide-valve in the inverse order and on the opposite side of the piston, while the motion of the piston and driving wheels still continues in the same direction as previously; in the first portion of the stroke, therefore, the cylinder is open to the exhaust on the front side of the piston, but in the latter portion the steam, at full boiler pressure, is admitted, and opposes the forward motion of the piston. In the return stroke the front of the piston, in ordinary working, is in communication with the exhaust until nearly the end of the stroke; but in the reversed working it is to the back of the piston that the exhaust is open, and the piston accordingly draws in the heated gases from the smoke-box at atmospheric pressure, and in the next forward stroke the contents of the cylinder are compressed as soon as the exhaust port closes, and forced by the piston into the boiler against the full pressure of steam. The latter portion of each stroke of the piston is thus made against the full boiler pressure, which resists the motion of the piston, and consequently acts as a powerful retarding force to check the rotation of the wheels in the direction of running.

The simple and efficient plan designed and carried out by M. Le Chatelier for counter-pressure working consists in introducing a small jet of hot water from the boiler into the base of the blast-pipe

of the exhaust port of the cylinder; this jet being discharged at boiler pressure into the atmospheric pressure of the exhaust passages, the greater portion of the water instantly flashes into steam at atmospheric pressure, and instead of the heated gases from the smoke-box, a moist vapor or fog is now drawn into the cylinder behind the piston. The rubbing surfaces are thus maintained constantly lubricated by the presence of saturated steam, and all heating or cutting is entirely prevented. The jet of water is regulated so as to be always slightly in excess of the precise quantity required, the object being to prevent the possibility of drawing in any of the heated gases from the smoke-box; and the constant escape of a slight cloud of steam from the chimney affords an indication to the driver of the sufficiency of the jet. Mixed jets of hot water and steam in various proportions have also been employed in particular cases of working. The use of the counter-pressure working has the important advantage of rendering the great weight of the engine available as brake power; and as the amount of retarding power obtained from the counter-pressure steam against the pistons when running reversed is less than the propelling power of the steam in ordinary working, the engine wheels are not skidded upon the rails; but a steady retarding force is continuously applied to them within the limit of their adhesion. The wear of rails and tyres that is caused by the friction of the train wheels when skidded by the ordinary brakes, and the consequent injury to the wheels by wearing flat places in their circumference, are avoided to the extent that the counter-pressure steam is used as a brake on the engine; and the practical working of the counter-pressure plan has been found so satisfactory, that its use has even been carried so far in many cases as to supersede the employment of the train brakes, not only in descending inclines, but also in stopping and shunting at stations. In shunting, the steam regulator is left constantly open, and the motion of the engine is controlled entirely by the reversing handle. The employment of the counter-pressure working has now been extensively adopted in France, Spain, and other countries, as many as 1,400 locomotives being regularly worked on this plan on the Paris and Lyons Railway alone, both in descending inclines and in stopping and shunting at stations; and in all cases its adoption has been attended with complete success.

The Fairlie Engine and Steam Carriage Company, in a communication to the "Engineer," write:

"We have very carefully investigated every description of brake that has yet been proposed, and at last decided that the Le Chatelier brake was superior to all others, because of its great simplicity and its wonderful efficacy. Before definitely deciding, however, we spent some time with M. Le Chatelier on some of the principal lines in France, inspecting and testing his system with long heavy trains on steep inclines and heavy shunting work at stations. In no case was there ever the least difficulty, the driver regulating or stopping his train by simply opening or shutting a small tap placed ready to his hand. In one case with a train of 326 tons, including the engine, we ran from Commentry to Moulins on the Paris and Orleans Railway, distance 104 miles. From Commentry to Villafranca, there is an average descending gradient of 1 in 60 for 10 miles, down which we ran without the assistance of any brake whatever, the little tap on the boiler doing all the work. We varied the speed at pleasure—now 15 miles an hour, now 10, now 12; we no sooner desired an increase or reduction of speed than it was accomplished, so beautifully did the apparatus work, and all done by simply altering the position of the steam and water taps. The cost of supplying the apparatus, and fitting the same to any ordinary engine will not exceed £20. The whole arrangement is simple, although the steam and water taps require to be very carefully and nicely regulated, also the nozzles of the jets in the exhaust pipes require to be very carefully directed.

"We have just completed a series of experiments made this day with the 'Progress,' with the counter-pressure brake, and the result has proved most satisfactory. With a train between Hendon and Kentish Town, the gross load of which was 650 tons, we stopped on a gradient (the rate of grade at this moment we do not know), in 300 yards, the speed being fully twenty miles an hour at the commencement of applying the back pressure."

ROTARY STEAM-ENGINES AND HOT-AIR-ENGINES.

Translated from "Der Practische Maschinen Constructeur."

That kind of steam-engines in which the expansive power of steam acts directly upon rotating parts (pistons) is illustrated by a great number of plans and models, but by very few machines in actual operation. And these will have but a brief day for their limited sphere of use, as their performance is not for a moment to be compared with that of machines with reciprocal or oscillating piston motion. Why are all existing constructions of rotary steam-engines useless, and why do men continually labor to invent new machines of a kind proven to be the least effective of all? Those machines in which the principal parts are free from all alternating motion are in such a primitive condition, and so little suited to the properties of steam, that they may well be called playthings. A single notable exception is the machine of the Patent-Disc-Engine Company. And this has the fault of all rotary steam-engines—great friction and little steadiness. The second class of machines, in which, besides rotary pieces, there are also driving or driven pieces which have reciprocating motion, are only bad modifications of the present cylinder machine, in which rectilinear movement is in the simplest possible way converted into rotary. In this sort of engines we meet with ridiculous notions, and we find it hard to understand how practical men can run so wild in pursuit of novelties. It must be granted that very ingenious constructions are somtimes devised. But in all there is the same fault—very great friction or lack of stability, or both. Every practical man of moderate experience in this direction knows how difficult it is to steer clear of these defects.

A power of little intensity, but great quantity, can be increased in intensity if it be taken up and delivered or translated at a proper velocity. A body will acquire a much greater mean velocity by revolution than by a rectilinear oscillating motion. It will take up and impart a much greater quantity of power working uniformly, and will do so without requiring more room. A turbine requires but a fraction of the room required by an ordinary water wheel using the same quantity and the same head.

There would be a like difference between the space occupied by a rotary and a cylinder engine, if we could but assume that the useful work of the two is equal.

This fact, the dispensing with heavy regulators, and the illusory assumption of a greater useful effect, have been the motives in the construction of rotary engines. As long as inventors attend to these points only, and their effort is directed to change of the corresponding mechanism, so long will it be hard for rotary machines to claim attention as useful working engines.

We shall find other helps to the solution of this problem by a critical consideration, not of the mechanism, but of the peculiar principle of these engines, and the properties of their corresponding motive powers.

(1.) A permanent gas under a pressure of 0.5 atmospheric, friction taken into account, flows through an opening of 10 centimetres with a velocity of about 250 metres a second. If the gas, instead of flowing freely, drives a piston which moves with only 0.1 of the velocity of the gas, it would move 25 metres in a second. How long would machines with some parts affected by alternating motion hold together? Such velocity, and greater, can be given without damage to revolving parts only.

(2.) Suppose the pressure of the gas to be 0.5 atm., equal to 0.515 kilog. per. sq. metre, and the velocity of the piston to be 25 metres; a piston of 10 centimetres area would give a work of 129 sec.-kil. or 1.7 H. P. If a machine could be made giving 0.1 effective work, then the piston that is to do the work of 1.7 H. P. must have an area of 100 sq. centim., while the engine itself would need but small dimensions.

(3.) To give a permanent gas a tension of 0.5 atm., for a constant volume, only 150° C. is neccessary. If 200° C. is taken to compensate for loss of heat, still this is low enough to prevent impairing the efficacy of unguents.

(4.) The more rapidly a piston is moved by the pressure of a gas, the less closely does it need to fit the side of the cylinder, since the friction of the gas in the narrow space between, does not allow a great velocity of transmission of gas; in fact, at the normal velocity of the piston it is entirely prevented, especially when the tension of

the gas is weak. Unnecessary friction, and the consequent loss of work and destruction of bearing surfaces, are thus prevented.

(5.) The advantages mentioned in (3) and (4) disappear when gases of high tension are used. Closer contact is necessary, and friction therefore increases; oiling becomes impossible, as unguents cannot resist the great heat.

Gases under high tension can give out their driving power with advantage, only when they work expansively, which makes a complex apparatus neccessary; and this, combined with a complex mode of operation of gas, puts difficulties in the way of rapid motion of a machine, while on the other hand friction gives more difficulties to slow motion.

(6.) The conditions are still more favorable when, instead of a permanent gas, steam is applied as a motive power. For its economic use, expansion and condensation are neccessary. In the generation of steam, its full operation, its expansion and its condensation, are involved processes on the one hand simultaneous, on the other sharply distinct, which may not follow close one upon the other if they are to produce effective work. The speed of steam-engines must not be too great for useful work. Herein lies the chief advantage of rotary machines, because of the rapidity of motion that can be turned to useful effect. Slow motion brings with it the defects already mentioned, and adds to cylinder machines not one advantage which is not cancelled by some equal disadvantage. Experience has shown this, and theory has proved it.

(7.) Hot-air engines in their present form must be of great dimensions, and out of proportion, in order to produce work of any account. Besides, an extraordinary heat is required for the neccessary tension. Under these circumstances there remains the unsolved problem—to furnish a simple and effective contact, to oil the working parts well, and to prevent heated parts from quick destruction. The defects will remain so long as we make hot air work in cylinder engines, which cannot convert weak tension into quick motion.

What has been said sums up as follows: The peculiarity of rotary machines is, not that they drive by means of steam or of intensely heated permanent gas of high tension, but that they drive by means of a permanent gas to which a moderate tension is given by heating to about 200° C. On the other hand, steam, not heated air, is suited to the cylinder engine. The mechanism which takes up the force and converts it for our use must be fitted to the force; so steam and cylinder engines consort, and hot air with rotary engines. The rotary engine makes the conversion of heated air into motive power possible, while the application of heated air as a motive power makes a corresponding construction of a rotary machine possible. If the mutual harmony of machine and of power is recognized, the joining of both in a harmonic whole will not be wanting.

The Age of Iron.—In these islands alone 500 blast-furnaces are blazing; reducing, by their intense heat, nearly 12,000,000 tons of iron ore to 4,800,000 tons of metallic iron, which, at its place of production, has a value of about £11,000,000 sterling. Those blast furnaces consume more than 14,000,000 tons of coal; and to convert the pig-iron obtained into bars, rails, and the like, a like quantity of coal is required. The great iron industry is not confined to the British Isles alone. In France it is no less active, and it boasts of iron-works which rival those of Dowlais, of Barrow, or of Middlesbrough. The works of Messrs. Schneider & Co., at Le Creusot, the largest in France, have 50 acres under cover. Here are 15 blast-furnaces, with 27 steam-engines blowing air for them, and forging iron besides. At the mines and works over 3,500 men are employed. Belgium, Prussia, Austria, and Sweden are active in this great race; and America is striving, with earnest and honorable zeal, to overtake Europe in the production of iron from her native ore, with her own coal.

A writer in the "Times" proposes, as amongst the best means for preventing railway accidents, that station platforms should be raised to the level of carriage floors, and brought within 3 in. of the carriage sides; that a net should be fastened over the spaces between the carriages, and that engines should be fitted with an apparatus in front in the shape of the mould-board of a plough, and adapted to throw all obstacles out of the way of the train.

LONG AND SHORT SPAN RAILWAY BRIDGES.

By John A. Roebling.

A brief reference to the contents of the work referred to above will be of interest to our engineering readers.

The theory of the parabolic truss is set forth with great clearness, and without the use of troublesome formulæ, and is followed by details of arrangement and calculations of strains for spans of 500 ft.

In illustration of the use of the parabolic truss, in combination with a system of stays, two cases for spans of large magnitude are given. One of a central span of 500 ft. and two side spans of 300 ft. The other, of a central span of 600 ft., and side spans of 420, besides minor side spans of 150 ft. Some of the designs were prepared for special localities, but can be adapted to every possible range of profile and situation, and for every length of span desired.

For spans above 600 ft., the combination of the upright and inverted arch is replaced by the pure suspension principle, stiffened by a truss, which is provided with sliding joints at the ends of the stays, to provide for expansion and contraction, both towers being fixed in this case. The illustration presents a main span of 800 ft., and two side spans of 548 ft.

Engravings on a large scale, and of the highest excellence, exhibit the structure as a whole in a most impressive manner; to which are added the details, on a larger scale, of combination and dimensions, and tabular statements, with weights and estimate of cost of construction.

There are also given the means and manner of erection of such large spans, without obstructing the iron by scaffolding.

A large amount of engineering information is thus given in a most complete and practical manner.

Three other designs of bridges of large span show the different modifications of the parabolic truss principle. The tension of the cable, instead of being taken up by an anchorage, resists the thrust of the arch directly, by an anchor-plate. The arch may be cut off at any point of its curve, to suit the convenience of site in determining the length of land spans.

The structures throughout are of iron, including wrought-iron towers on the stone piers. One tower is fixed on its pier; the other tower, with the rest of the structure, being free to go and come.

The designs for the short-span bridges are accompanied by reference to the circumstances and considerations which determine where the parabolic system can, and where it cannot, be used with economy.

It will be noticed that the unit of load adopted is considerably above the unit ordinarily adopted, and that fact must be borne in mind when making comparison with the known cost of other structures.

The six tables of weight and cost of trussed girders for spans of 200 to 400 ft., with and without wire cables of iron or steel, include the statement of strains and sectional areas and units of tension and compression, and are thus of the highest practical value.

[We insert the introduction to Mr. Roebling's work, that our readers may have the privilege of reading the last published words of the great engineer. —Ed.]

INTRODUCTION.

No continent can boast of a more magnificent system of water-courses than ours, and on no other continent will there be a greater development of internal commerce, by land as well as by water. The construction of long-span railway bridges over our large navigable rivers, such as will not materially interfere with their free and easy navigation, becomes therefore a question of national importance.

Who can estimate the tonnage of the future (say one or two hundred years hence), which will be floated upon our navigable water-courses. Considering now that this immense tonnage will have to be moved at low rates, and that this can only be done on the *barge* system, and that large tows, measuring from one to two hundred feet across, require ample water-way in passing a bridge, and that they cannot, without great risk, be exposed to oblique currents, produced by the close proximity of piers, the necessity of large openings in bridges becomes self-evident.

Another important consideration in favor of long spans is presented by the

fact that foundations in the large rivers of the West, in order to be safe, must be sunk to the rock, else their security will be endangered by the deep scour caused by floods. This depth of scour may be caused by an ice-flood, when narrow spans are apt to produce ice-gorges, and thus force the current to undermine shallow foundations. But deep foundations are expensive, because the stability of piers of 150 to 250 ft. high requires a broad base and a corresponding mass; hence the economy of larger spans, by decreasing the number of piers, is apparent at a glance.

Economy in construction will be the test of the future. Sooner or later those plans and systems alone will survive in practice which are the most economical; those alone will be adopted by the competent engineer which will afford the greatest amount of strength for the least amount of cost.

Ever since the question of suspension railway bridges has been discussed, the opponents of this system have never objected to it on the score of economy; on the contrary, they are always willing to yield this point. Their apparently insurmountable objection is the inherent flexibility of such structures—great enough in imagination to endanger the safety of passing trains. The utter groundlessness of this objection having been demonstrated by the complete success of the Niagara bridge, the low speed of trains maintained on this work is now made another potent argument.

To meet this I will draw the attention of those who have not made up their minds on the subject, but who honestly seek further information, to the fact that all the large wooden railway spans, whose safety has never been doubted, are, in proportion to the span, more flexible than is the Niagara bridge. All iron bridges are flexible, because of the elasticity of the material composing them. But wooden structures are more so. A wooden truss of 200 ft. span, after a few years' use, will readily yield from 3 to 4 in. in the centre under the passage of a heavy train. The deflection of the Niagara bridge when taxed with a fully loaded freight train, from end to end, is 10 inches, and this is principally owing to the straightening of the anchor cables. Suppose an ordinary wooden truss was lengthened out to 800 ft., and suspended by cables, its flexibility would be about the same as that of the Niagara bridge, and less in proportion than the 200 ft. span *without* cables. Now has any engineer objected to our wooden railway bridges on the score of flexibility? The man who did would be laughed at.

I here repeat what I have said on former occasions, that the principle of suspension will of necessity become the main feature in our future long-span railway bridge.

Theoretically considered, the principle of the arch, in an upright as well as in a suspended form, is the most economical. It will hold equally good in practice, if properly applied. To obtain the largest degree of economy, however, the two positions of the arch, the upright as well as the inverted or suspended, must be combined into one united system; and this system is now well known, and was equally well known in the last century, as the *Parabolic Beam*, or the *Parabolic Truss*, as I prefer to designate it. The principle of the Parabolic Truss forms the main feature of the plans herewith presented. It has been applied with a view to economy as well as stiffness.

As to novelty of invention I claim nothing. Most of the combinations may be, and no doubt are, novel; but they are only different illustrations of the same old and well-known principle.

To prevent and forestall the issue of trifling patents, such as would be a disgrace to the American profession of Civil Engineers, is one of the objects of this publication.

In the nature of things, no plan can be devised for large central railway spans, with lesser spans adjoining, which offers equal strength and stiffness at the same low cost as does the Parabolic Truss as here designed. For large single spans, and for openings exceeding 700 ft., the pure suspension plan with a judicious system of stays and trusses, as is found in the Niagara and Cincinnati bridges, will be most economical, and sufficiently stiff for all railway traffic.

These statements may appear at the first glance rather positive, but by and by they will stand out no longer as individual opinions, but they will establish themselves as *great engineering facts*, and moreover an *American necessity*, because we have to deal with large navigable rivers;

and navigation will not be suffered to be destroyed by incompetent engineering. Ignoring minor attempts, the first successful endeavor to apply the Parabolic Truss on a large scale is due to the late Mr. Brunel; who, in the Saltash bridge, has left a remarkable proof of his practical genius.

Without copying Brunel's model, the same system has found very extensive and successful application on the continent of Europe, and is more particularly known in Germany as Pauli's system. The largest and most noted work in that country, built upon this plan, is the railway bridge over the Rhine at Mayence, with four river openings of 101.29 metres each in the clear, equal to 322 ft. 5 in., English measure.

Within the last year a distinguished Austrian engineer, a man of great practical experience in iron railway bridges, Carl von Ruppert, has published his magnificent plan for a great railway bridge over the Bosphorus, near Constantinople, with a central opening of 650 ft. (Austrian measure) and two side spans of 513 ft. in the clear.

Without entering upon the details and general merits of this justly celebrated design, it must be acknowledged that it is a most beautiful application of the principle in question. But on the score of economy, safety, and cost, this design is much inferior to a pure suspension bridge, which, without any costly piers and foundations in a deep sea channel, may be thrown across this famous strait, from shore to shore, in a single span of 1600 to 1700 ft.

In this number the plans and estimates are given of a bridge spanning a centre opening of 500 ft. in the clear, with two side openings of 300 feet each; also the plans of the St. Louis bridge. In order to enable the practical engineer to make all those calculations which are really necessary for determining the principal strains and forces, I have also introduced a few theoretical considerations. Elaborate theories are out of place in a work designed for practical men alone; they may be found in every standard work on Statics and Mechanics.

As time and health shall permit, other plans will be prepared, to follow this number, designed for long spans as well as short.

JOHN A. ROEBLING.

TRENTON, N. J., *Sept.* 1, 1868.

THE LONDON WATER SUPPLY.

From "Engineering."

It is more than two years and a half since the committee appointed to examine into the condition of the Metropolitan Water Supply, commenced their labors but recently terminated, these being recorded in a report, the conclusions of which we have already published. The probable future metropolitan water requirements, and whether the source whence its present supply is derived will be sufficient and reliable in all ways for the coming generations, or whether we should begin to look elsewhere than to the Thames Valley for our main supply, were the questions which the committee had to set themselves earnestly to consider; and, judging from the voluminous evidence they have received, from the personal examinations they have made, and from the care with which they have weighed evidence and studied the physical peculiarities of the basins of the Thames and of the Lea, we are bound to assume that their recommendations are correct, and that the Thames and the Lea, which have hitherto supplied London with water, will never fail, either in quantity or quality, in serving the metropolitan demand, even though it should grow and extend itself in a proportion which the increase of the decades of the past does not warrant in assuming for the future.

Two hundred millions of gallons of water a day is estimated as the future necessary supply for a population swelled to 5,000,000; nearly 200,000 tons of water distributed over an area of 224 square miles, through mains and branches and service pipes to meet individual demands, or public wants; forty gallons being apportioned to each unit of the 5,000,000 every day. Times are changed, and necessities have increased since the city ran with sparkling streams from the high lands

on the north of London, and carried a plentiful supply, which could be had for fetching; or since the local springs were collected and led by conduits through the city. The streams have long since disappeared, changed into sewers, arched over out of sight, and nothing but the names are left of the conduits to mark the course along which they ran. But these supplies were too limited even for London of the sixteenth century; and three hundred years ago came Peter Morrys, the Dutch engineer, who utilized the constant flood pouring through the narrow archways between the piled-up starlings of old London Bridge, to drive pumps that raised water and supplied, by wooden mains and by open gullies, the neighboring streets for two centuries after his time.

In 1609, Hugh Myddelton commenced the formation of the New River, bringing the springs from the chalk at Chadwell and Amwell, near Ware, to within a few miles of London. Funds failing him then, the work was completed by the help of a royal grant, in doing which, by the way, royalty looked well after its own interests, and thus, seven years after the act had been obtained, the northern parts of London were supplied by a plentiful flow, secured by gravitation. Soon after its completion the waters from the chalk springs, which originally formed the only source, were supplemented by an inlet from the Lea.

These two works, together with the natural streams and open conduits, formed the water supply to London till the end of the seventeenth century. But in 1691 a company was formed under the title of the York Buildings Water Works Company, to supply the city of Westminster, the water being pumped from the Thames near Charing-cross. These works existed so late as 1829. In 1723 came the Chelsea Water Works to supply a district of Westminster and the growing neighborhood westward. At first the pumps were erected at Millbank, and afterwards removed to a site near to the present Victoria railway bridge. Meanwhile, the narrow arches of old London Bridge were filled with water wheels that clumsily raised water for the city as well as for Southwark. In 1785 the Lambeth Works had started and pumped their supply from the Thames opposite Charing-cross, and the Borough had established pumps not far from Blackfriars Bridge. With the beginning of the century most of the companies which now supply the metropolis came into existence. The West Middlesex Water Company at Hammersmith in 1806, to supply the western suburbs; the Grand Junction, five years later, who, starting to draw their water from the Colne and the Brent, aided by surface drainage, soon had to resort to the Thames for a purer and more constant supply, and in 1820 their sluices drew from the river near to Chelsea Hospital. Eastward the East London Water Works, dependent for their supply upon the river Lea, superseded two small establishments at Shadwell and Ham; and shortly after their act had been obtained, in 1806, works were erected near Bow. In the southern districts the Vauxhall Water Works were started in 1805, taking their supply from the Effra, then an open confluent of the Thames, and but recently converted into a covered sewer. The various companies thus established, before long, trading on their monopolies, began to levy rates, which resulted in a continued public dissatisfaction, and in 1821 a commission was appointed to examine into the subject. Their report, recommending considerable reform, was never officially acted upon, but it had the effect of inducing the water companies to remove the chief cause of complaint. The quality of the water supplied was the next subject that claimed general attention. The various companies drawing their supplies from the river, polluted by the sewage discharged into it, distributed it direct throughout their respective districts without any intermediate process of purifying. In 1828 a commission was again appointed to inquire into the quality of the supply. The examinations conducted by this commission showed that the general outcry was a just one, and that the supply, especially from the works below Westminster Bridge, was totally unfitted for general use. Filtering beds, settling reservoirs, and removals to new sites followed the publication of this report. The Chelsea Company, in 1829, laid down the first large filter of one acre in extent; the West Middlesex and the Grand Junction removed their source from Chelsea to Brentford; the East London went higher up the Lea, and the Southwark and Vauxhall, combining, established new works at Battersea.

A report by Mr. Telford was made in 1834, in which it was recommended that entirely new sources of supply should be sought, and in which Mr. Telford suggested the Verulam on the northern, and the Wandle on the southern, side of the metroplis; but this report, although discussed in both Houses, remained entirely unacted upon.

The partial improvements introduced by the various companies after 1828 tided matters over for several years, but the development of sanitary engineering resulted in so largely increased a discharge of impurities into the river, that an efficient filtration became impossible, and it was obvious that the time had arrived when some of the most important companies must change their source of supply, or abandon their works altogether.

The Lambeth Company, situated in a most unfavorable position, were the first to take active steps towards the unavoidable change. In 1848 they obtained a new act, and three years later water drawn from Kingston, far beyond the influence of the tide, was delivered through the mains of these extensive districts.

In 1850 the General Board of Health, who had by that time developed into a most useful and powerful body, issued a report, the minutes of which pointed out strongly the evils existing from the system of deriving a large supply from the tideway of the Thames, and, indeed they went so far as to assert that the river should only be utilized temporarily for obtaining water beyond the influence of metropolitan drainage, until a more favorable locality could be decided upon, and centralised works erected; and they pointed out the large tract formed by the Bagshot sands, and the lower greensands in Surrey, as suitable for the purpose. This proposition might possibly have been acted upon had not a company at that time been projected for the purpose of supplying London with spring water from the chalk at Watford. The scheme had been so favorably noticed by Robert Steppenson, in a report made ten years before, that it was thought advisable for a commisson to investigate chemically the quality of the water obtainable above the tidal influence. The result of their inquiry showed that such water could be thoroughly relied upon for public use, and, condemning the Board of Health proposition relative to turning to the Bagshot sand as a source of supply, they recommended the consideration of the Watford scheme, assuming that the hardness of the water derived from chalk could be destroyed by Dr. Clark's process of softening.

The termination of all these investigations was a decision that legislation on the subject was necessary, and in 1851 a bill was introduced into Parliment for the amalgamation and centralization of all the water companies, and the obtaining of all water from one common source. Opposition overcame this measure, but it resulted in an act being passed the following year, by which stringent and important obligations were imposed upon the various companies, who were left otherwise free to pursue their business independently. The most important clauses of this bill rendered it compulsory that no water should be drawn from the river below Teddington; that all the city storage reservoirs should be covered; that all water, unless pumped from wells should be effectually filtered.

After the passing of this bill, the water companies proceeded to make alterations in compliance with its clauses, which involved an expenditure of £2,500,000, and with the result, ascertained in 1856, of considerably reducing the amount of organic matter.

Of the eight companies now supplying the metropolis, five are situated on the north side of the Thames, and three on the southern side. In the long series of articles published in the second volume of "Engineering," under the title of "The Waterworks of London," the whole of these works were fully described in detail.

The number of gallons given in the last column of the following table, as the amount of daily supply, gives only the average, and not the maximum quantity, which in the summer months is augmented to 108,313,000 gallons, showing an excess of 10 per cent. of consumption in the summer over the winter months.

Collectively, the various companies possess forty-four subsiding reservoirs, occupying 260½ acres; the filtering beds number forty-eight, with an area of 51⅛ acres; they own twenty-eight storage reservoirs, having a capacity of 112,087,000 gallons; and ninety-six pumping engines, of 10,660-horse power in all.

Table giving the General Statistics of the various Establishments in 1867.

	CAPITAL.	APPROXIMATE AREA OF DISTRICT SUPPLIED.	NUMBER OF HOUSES SUPPLIED, 1867.	ESTIMATED NUMBER OF PEOPLE SUPPLIED, 1867.	AVERAGE DAILY SUPPLY, 1867.	
From the Thames:		Square Miles.			Gallons.	
Chelsea Company...........	£785,600	6.5	26.875	170,000	8,087,258	
West Middlesex............	798,571	10.0	36.881	275,000	8,816,486	
Grand Junction............	850,000	24.0	27,190	245,000	9,533,432	
Southwark and Vauxhall....	1,100,440	30.0	71,558	465,000	13,629,758	
Lambeth..................	736,245	25.0	38,320	230,000	8,975,530	
						49,042,467
From the Lea:						
New River Company........	2,609,418	19.0	113,462	800,000	23,790,667	
East London Company......	1,400,000	50.0	92,652	675,000	19,298,241	
						43,088,908
From chalk well, Kent:						
Kent Company.............	489,240	60.0	34,504	240,000	6,468,873	6,468,837
Total................	8,769,514	224.5	441,442	3,100,000	98,600,248	98,600,248

By their present acts and agreements, the companies are empowered to draw 110,000,000 gallons daily from the Thames—the Chelsea, West Middlesex, Grand Junction, Southwark and Vauxhall, and Lambeth Companies, each taking 20,000,000 gallons, and the East London Company (under a recent act), a quantity equal to 10,000,000 gallons. From the Lea, the average quantities actually taken, are : 18,000,000 gallons by the New River Company, their total delivery being 23,750,000 gallons; and the East London take 19,250,000 gallons from the Lea, at a point lower down the river. Besides these quantities, the chalk wells of the Kent Company yield 7,000,000 gallons daily.

The Commission of 1865, appointed to inquire into the best means of preventing the pollution of rivers, reported that the accumulating sewage discharged into the Thames by all the towns and villages along its course, tended seriously to impurify the river, and that efficient means should be taken to compel the diversion of the discharge, and the utilization of the sewage upon the land. The report resulted in the act passed the following year, which legislated for the towns along the Thames Valley, and fixed a limited time for the completion of the dictated improvements, a limit which, by the way, has been exceeded hitherto with impunity. This commission, and also the committee appointed in 1867 to inquire into the condition of the river Lea, were of opinion that with the recommended alterations, both rivers were efficient sources of supply, and that there was nothing to justify incurring a vast expenditure in the formation of new works.

The lengthened discussion which had taken place, and the epidemic which visited London in 1866 (the cause of which, it was alleged, might be traced to the water supply), brought forward many schemes for obtaining a pure supply from a foreign source; of these the principal were Mr. Bateman's project for utilizing the sources of the Severn; Messrs. Heman and Hassard's plan, looking to the Cumberland and Westmoreland lakes; Mr. Fulton's project for drawing water from the Wye; and Mr. Remington's plan of obtaining it from the Derbyshire hills.

All these different systems, which have been fully described in previous volumes of "Engineering," were carefully examined into by the recent committee, who concluded that, setting aside all other considerations, there was not sufficient information upon the reliability of the rainfall. "It is evident," they say, "that a long series of observations is necessary to be made before any authoritative opinion can be expressed, not only as what may be the true average rainfall, but what may be the mean of the three driest years, and at what intervals they occur. In the case of a large city like London, where such a source of supply is proposed, an exact determination seems to us imperative. Of

course it will be understood that not only should the observations extend over a long series of years, but also that they should be made in many places so as to get at the average rainfall of the district, which has well been shown to have very different values in immediately adjacent places, as it varied in the same year in fourteen areas in the lake district, from 45 to 100 in. The system of collecting grounds utilizes, no doubt, the rainfall to the greatest extent. But the great disadvantage is, that the springs to fall back upon in time of drought are insignificant in comparison with the great quantities stored in permeable strata. The very circumstance of a large immediate delivery of the rainfall, precludes the possibility of that subterranean storage of a large portion of it, which forms so valuable a resource during severe and long-continued droughts."

These objections are substantiated by the experience gained from towns furnished with gravitation—supplies which have in nearly all cases failed in seasons of drought, when the requirements were the most urgent. Liverpool, Manchester, Newcastle, Rochdale, Preston, Bradford, Halifax, and other towns supplied by this system, have all suffered from a temporary deficiency, or even an absence of water, which involved the hasty extemporizing of other means to meet the unexpected demands, or the erection of permanent pumping works to supplement the insufficient ones already existing.

THE HEATON STEEL PROCESS.

MONSIEUR GRUNER'S REPORT.

From "The Engineer."

We lay before our readers an English translation of the long-expected memoir on the Heaton steel process, by Monsieur L. Gruner, the eminent Professor of Metallurgy of L'Ecole des Mines, Paris.

THE HEATON PROCESS.

The purification of pig-iron by the Heaton process is based on the reaction of nitrate of soda, which is at once basic and oxidizing. The nitric acid oxidizes the silicon, the phosphorus, and the sulphur; the soda seizes on the acids so formed, and withdraws them from the reducing action of the iron. These reactions are known, but the difficulty in operating on large masses is to obtain a sufficiently intimate contact between the molten metal and the nitrate to produce an efficient purification, without, however, causing an action so energetic as to result in violent explosions. Mr. Heaton adopted several contrivances in succession, which I need not review. It will be sufficient to describe his latest improvement, which has the great merit of being both simple and cheap.

This apparatus consists of a cylindrical vessel with a movable bottom, a kind of cupola without tuyeres, into which is run the molten metal to be purified. In England it is called a Bessemer's converter. The movable bottom is a cylindrical cauldron of sheet-iron, provided with two trunnions, which allow of its being held by a forked lever mounted on a wheel carriage. By this means it is removed and replaced after each operation. The interior of the cauldron is lined with bricks or refractory clay, worked into the shape of a hemispherical basin.

The converter and its movable bottom are provided with flanges which are held together by clamps and wedges for each operation. The converter itself is lined with fire-bricks, and provided with a sheet-iron chimney like a cupola; on the top of the chimney is a sheet-iron cap, intended to stop the projection of incandescent slag and metal, which might take place in the event of a too violent deflagration of the nitrate. The molten pig is poured into the converter through a lateral aperture, a sort of box funnel, which can be closed at will by a wrought-iron lid, or simply by a brick. The dimensions vary with the weight of metal to be treated at each operation. There are four converters at Langley Mill, two large and two small ones, the latter are used for charges of about 15 cwt., the former ones for more than double that quantity. But that is not the necessary limit of their capacity; like the Bessemer converters,

they can be made of any size, and, as in the Bessemer process, on account of the heat absorbed by the lining of the converter, the operation, within certain limits, is the more uniform as the volume of metal treated is increased. Still the process is successful even where the charge treated does not exceed 2 cwt. The interior diameter of the 15 cwt. converter is 29 in., and the depth of the bottom is about 12 in. The distance from the spout of the box-funnel, into which the molten metal is run, to the bottom of the nitrate chamber, is 4 ft. 3 in., and from the same funnel to the top of the vessel 36 in. Above this is a simple chimney of sheet iron, slightly conical, the height of course depending upon the height of the roof of the works, through which it has to be carried. The large converters for 3 tons have an interior diameter of 39 in., and the depth from the funnel to the bottom about 78 in. The molten metal to be purified may be taken direct from the blast furnace, and in fact it ought always to be so, unless, indeed, the modifications I shall presently recommend be adopted. Treatment direct from the blast furnace was the method pursued at the Stanton Works near Trent, in the Erewash Valley, while at Langley Mill itself, there being no blast furnace, the pig is run down in a common cupola. But this arrangement is simply experimental, and not to be taken as a model for imitation in the erection of new works. The essential feature of Mr. Heaton's invention lies in the arrangement of the nitrate chamber. To insure the gradual decomposition of the salt by the molten metal, the nitrate must be tightly packed into its chamber, and further protected by a perforated cover. If the stream of molten metal fell directly on the nitrate, it would at once penetrate and force its way to the bottom of the mass. The action would be most violent and instantaneous, and the alkaline salt would soon float without efficiently permeating and reacting on the molecules of metal to be purified. To avoid this, the above-mentioned perforated cover is placed over the nitrate when it has been packed into the movable bottom; it is a thin plate of cast or sheet iron perforated with a great number of holes about ½ in. in diameter. Mr. Heaton habitually uses a cast-iron plate of about ¾ in. in thickness; but a piece of thin sheet-iron seems to me better, and answers better in the little experimental 2 cwt. converter which Mr. Sharpe has lately erected at Villette near Paris. To prevent the displacement of the plate by the molten metal, it is held down by wedges of iron or brick. These wedges are laid between the plate and two flat iron bars laid across it, and nipped by the projecting flanges of the converter and the nitrate chamber; moreover, to prevent any leakage, the joint of the flanges between the bottom and the converter is futed by slightly moistened moulding sand. Then the clamps and the wedges bind them together and make all sure. When the converter has been thus prepared, all is ready for the reception of the molten metal to be treated. Having been present at some twelve conversions, I will first of all relate the general plan of operations. I will then give an account of the results obtained from the Moselle pig irons. I will proceed to give my analyses, which will show what degree of purification can be effected by this process. (I should say here that I visited Langley Mill in December, 1868, accompanied by Mr. Sharpe, an English engineer, acting for Mr. Heaton in France, Baron G. d'Adelsward, and M. Thiéblemont, engineer of the house of de Wendel et Cie, the object of our visit being to ascertain the effect of the process on the pig irons of the Moselle district.) The principal reagent used by Mr. Heaton is Peruvian nitrate of soda; but he habitually mixes with it a certain proportion of quartzose sand, some times lime, peroxide of managanese, fluor spar, etc. We shall see that quartzose sand and lime are more generally detrimental than otherwise, but peroxide of manganese, carbonate of soda, and sea salt may advantageously be added to the nitrate. Indeed, Mr. Heaton himself has abandoned the use of lime, and now generally uses from 6 to 12 per cent. of nitrate with 1 to 1½ per cent. of sand.

These two ingredients are thoroughly intermixed and then closely packed into the nitrate chamber, which has been previously dried.

The nitrate used is the ordinary nitrate of commerce; it contains from 5 per cent. to 6 per cent. of water, and 3 per cent. to 4 per cent. of foreign substances. A sample which I brought back from Langley Mill was analyzed at the School of Mines with these results: Water, 5.88;

sand, 0.28; sulphate of lime, 0.22; chloride of sodium, 2.73; pure nitrate of soda, 90.89. It was tested for phosphoric acid, but it only contained the merest traces of it. According to this, 100 of crude nitrate contains 33.27 of soda, or rather 34.7, if we reckon in that which is found in the condition of chloride of sodium.

The molten pig to be converted is tapped out of the blast furnace or the cupola into a ladle of sufficient capacity to contain the weight of metal to be converted. By means of a crane or a traveller the ladle is brought up to the box-funnel of the converter, and the molten metal is poured into it. If the molten metal be hot and fluid the reaction begins at once; the perforated plate lets the metal pass, the nitrate is gradually decomposed, the oxidizing gases, mingled with streams of soda, rise through the bath of pig and cause an ebullition more or less violent, which sometimes makes the whole converter tremble, and is accompanied invariably by a roar similar to that which is heard in a small Bessemer converter.

Throughout the conversion a vast volume of dense vapors issues from the top of the chimney; at first they are white, then yellow, orange, or gray, according to the kind of pig under conversion, and at last almost black; then, if the reaction be at all violent, the vapors take fire and burn for some seconds with a most intense yellow flame. When the reaction is less violent the gases only burn inside, then jets of flame sometimes force their way through the joints of the lid of the box-funnel. When the reaction is still more violent, or when the metal is not sufficiently fluid, there occasionally takes place, as in the Bessemer converter, some projection of incandescent slag and metal with showers of sparks; but there is never anything like an explosion. In some conversions the reaction at first seems very slow and feeble—there seems actually no commotion; then, all on a sudden, a violent action takes place with disfiguration and violent projections. This spasmodic action is doubtless caused by the sudden breaking up of the perforated plate and the consequent too violent irruption of the molten metal. This accident happens, in fact, when the plate is badly secured or cast of too brittle a material; on this account a plate of thin sheet-iron is decidedly preferable to a cast-iron plate. (In the small converter at Villette, which only holds 2 cwt., the metal is apt to choke the perforations of the plate if thin sheet-iron be not used.)

The conversion seldom takes more than from two and a-half minutes to five minutes, but occasionally, when the molten metal is not at a high temperature and cannot at once pass through the perforated plate, it lasts eight or ten minutes. The maximum duration of the vivid flame at the top of the chimney is one or two minutes. As soon as it has disappeared the vapors become lighter colored, and pass rapidly from black to light gray, and then to white. One can then open the lid of the funnel and, without any risk, observe the gentle ebullition of the metal at the bottom. It emits jets of yellow flame, and we can ascertain by an iron crow-bar the degree of fluidity and temperature of the refined metal. These both vary with the chemical composition of the pig treated. We shall see that silicious pigs give a very high temperature in conversion, as is the case in the Bessemer converter. When, however, charges of upwards of 18 cwt. are converted, the refined metal seems always fluid enough to be run into ingots or pig moulds, if the converter bottom were provided with a tap hole. This is not done at Langley Mill, and really there would be no great advantage in doing it, for the ingot would be entirely vesicular by reason of the gases which continue to escape in abundance as long as the metal is pasty; but the fact is none the less important to note, for it would allow of the purified metal being run out direct into another furnace to finish the refining.

At Langley Mill the metal is allowed to solidify in the nitrate chamber. When the ebullition has perceptibly diminished and the mass begins to solidify, the clamps are knocked off, the nitrate chamber is removed from the converter by means of the carriage lever above mentioned, and as soon as the metal has quite solidified the whole is upset and turned out on the plated floor of the works. The slag is separated from the solidified metal by means of hooked iron rods, and the metal itself is broken up by sledge hammers; even now we see numerous jets of yellow flame escaping from the incandescent mass. The refined metal, when entirely cooled, is more or less tough or

short, according to the proportion of the nitrate used and the original composition of the pig; the mass is cellular, like a great sponge. It is like the semi-refined metal which is taken out of the bottom of a "Comptois hearth" (four Comptois) at the commencement of the second period, to be submitted to the working (travail) properly so called. In the fresh fractures the metal is white, semi-crystalline, more or less granulated, according to the degree of decarburization, the vesicles are often iridescent, or even coated with a black film which is a little slaggy. The mass is certainly far from being homogeneous, as is proved by the look of the grain as well as by the analyses. Some portions are nearly iron or crude steel, what Germans call "wild stahl," which can be hammered; while others are more nearly allied to semi-refined pig or to finery metal more or less decarburized. This is what Mr. Heaton calls "crude steel."

The slags differ in composition, and correspond to the quality of pig treated. When the pigs contain a large percentage of silica, the slag runs into threads like glass. It shows a conchoidal fracture, and looks black in mass, but transparent and of a brilliant bottle-green color when broken off in thin chips. On the other hand, when there is but little silicon in the pig the slag breaks short, and solidifies quickly, as do all basic silicates. When cooled it is an opaque dull mass, of a brown-black or invisible green, having an uneven surface, showing a rough fracture, and being somewhat vesicular in structure. In either case the slag is full of globules of metal, and produces on the tongue the well known sensation caused by alkalies. The slags are attacked and partially dissolved by water.

The crude steel is treated in two different ways at Langley Mill. It is made either into wrought-iron or steel. In the one case some hundredweights are charged into a puddling furnace, the hearth of which has been raised with a view to its being worked simply as a balling furnace. To effect this object the hearth of the furnace is covered to a depth of some inches, with a mixture of sand and forge scales (*scoriæ de forge*) in equal proportions, well beaten down, and the sides are fettled with Cumberland red hematite; a charge of 6½ cwt., rapidly heated, is almost immediately welded into balls, which are then shingled into blooms under the tilt hammer. It is a kind of quick puddling, restricted to the time requisite for balling. The slags contained in the crude steel are liquefied and exude, and the finery process is completed simply by the welding heat. The actual process of heating lasts only half an hour; but as each bloom has to be taken back to the furnace for some minutes to undergo a species of balling before it is drawn out into merchant bars, the whole process in reality takes at least an hour. This balling enables them to dispense with piling, but when they want to produce superior iron they roll the shingled blooms at once into flat bars, rough, without any reheating. These are cut up, faggoted, piled, and rolled as usual. The total waste is 25 to 30 per cent. in this case; in the former, 20 to 25 per cent. The iron is tough and fibrous when it is piled, but hardly homogeneous. It is partly fibrous and partly crystalline when simply balled. Mr. Heaton calls this iron steel iron, but it is really ordinary malleable iron, which is in general hardly at all steely. In any event, to obtain malleable iron, of more or less tenacity, this process is too costly. Purification by the nitrate process is only feasible in point of cost, if the crude metal be converted either into homogeneous iron or cast-steel, and not into blooms; and this is the other method adopted at Langley Mill. The first product of the converter is, as I have said, crude steel, retaining still 1 to 2 per cent. of carbon. To convert it into cast-steel or homogeneous iron, the refining process must be completed, and the excess of carbon removed at the same time. To that end we must either use crucibles or a reverberatory furnace. Hitherto crucible melting only has been practised at Langley Mill, because it was necessary, in the first instance, to study the nature of the products. But this process is very costly, and Mr. Heaton always from the first intended to re-melt, on a large scale, in a reverberatory furnace. With this object, he had constructed a furnace with two combustion chambers, which was lighted on the occasion of our visit last December. The heat obtained was more than sufficient for the fusion of the metal, but the admission of an excess of air oxidized the metal and

converted it into slag. He would succeed better with Capt. Alexander's furnace (see my work on Steel, p. 74), and in any event with a Siemens furnace, such as is used by Mr. Martin at Sevreuil. At Langley Mill the re-melting has hitherto been done on the Sheffield plan, in crucible furnaces. Each furnace holds two crucibles, containing about 45 lbs. each. For convenience of charging, and to facilitate the selection of the different qualities of crude steel, which have to be mixed in the crucible according to the class of cast-steel which is required, the crude steel is hammered into flat cakes of about an inch in thickness, and these are broken up cold into small squares, just like the small pieces of cemented steel which are used for crucibles elsewhere. These cakes are prepared by heating the crude steel to a red heat in an ordinary reverberatory furnace, and then subjecting it to the action of the steam hammer.

As the crude steel retains an excess of carbon, and it is necessary to produce homogeneous iron or soft steel, pieces of wrought-iron are mixed with the cakes. For this purpose they use the crop ends of bars, or any other scrap iron of good quality that comes to hand. The cast-steel then is really obtained here by process of reaction, the admixture of a certain proportion of malleable iron with the purified pig. The refining can only be completed in the crucibles from which air is excluded by the ingredients contained in the metal itself, or added to the charge; and among these we must reckon the sodium, which is always present in small quantities in Heaton refined metal and metallic manganese, of which a small dose in the form of spiegeleisen is frequently charged into the crucibles. The reverberatory furnace has the additional advantage of the oxidizing action of air; so that, in reality, it possesses over the crucibles the double advantage of economy and of more completely refining the crude metal. But just now we have only to do with crucible melting. It only remains to be said that the operation is conducted in the usual manner, and followed by the tilting and drawing out of the ingots, in which there is nothing special to note, so I may as well pass on at once to a more detailed examination of the conversions I witnessed at Langley Mill.

I.—DEPHOSPHORIZATION OF THE PIG.

There were two brands of pig treated—the one from M. de Wendel's blast furnace at Hayanges, in the Moselle; the other from the Baron D'Adelsward's Priory furnaces near Longwy, in the same department. At both works the well-known oolitic ores of the upper lias of this district are exclusively used. The furnaces are worked with coke, and the hot-blast, and at full drift. But the pigs sent to Langley Mill were of totally distinct qualities. The Hayanges brand was a gray foundry pig, large-grained, and very graphitic. In England it would be classed as between No. 1 and No. 2. The Longwy pig was white, verging on the mottled. It may be classed as Forge Pig No. 5. It had been run into moulds and chilled with water. The two pigs were run down by themselves in a common cupola; about ¼ per cent. of fluor spar was used as a flux, the better to slag the coke cinders. Samples of the molten metal were taken for analysis before it was run into the converter. These are the results obtained:

	Hayanages gray pig, remolted.	Longwy white pig.	Longwy white pig, remolted.
Silicon.........	3.024	1.050	1.015
Sulphur........	0.090	0.350	0.333
Phosphorus....	1.275	1.650	1.485

HEATON PROCESS.

I did not look for the other constituents, but I ascertained the presence of manganese and a notable quantity of vanadium in all three samples. The two analyses of the Longwy pig show that the remelting in the cupola has not sensibly modified the composition of the metal. A very slight purification is, however, perceptible.

EXPERIMENTS ON LONGWY PIG.

For each conversion the cupola was charged with 14½ cwt. of pig. The molten metal was not weighed before being run into the converter, but we may reckon upon a waste of 7 per cent. by slagging, burning off, runnings and shell, linings, etc., which would reduce the charge of the converter to 13¼ cwt., or even to 13 cwt. 17 lbs., if we deduct a quarter of the residue found in

the cupola after four conversions. To these 665.75 kilos. (13 cwt. 17 lbs.) we must add 120 lbs. for the weight of the perforated plate, 12 lbs. for the two iron bars. The total weight of metal was therefore 725 kilos. (14 cwt. 55 lbs.), of which 720 kilos. (14 cwt. 44 lbs.) were pig, and 5 kilos (11 lbs.) iron. The experiments began with four successive conversions of Longwy pig. The weight of metal was the same in all four, but the charges of nitrate were varied. I will particularize the charges and note the special phenomena of each conversion. First conversion: There was charged into the converter, nitrate of soda, 150 lbs., or 9½ per 100 of the weight of pig; silicious sand, 20.

The molten metal ran very hot into the converter, so reaction was at once very violent; the gases almost immediately kindled at the top of the chimney. The yellow flame lasted two minutes, then appeared the black smoke, which gradually subsided, as did also the ebullition. All was over in four minutes. The nitrous gas was imperceptible. It seemed to be masked by the black vapors and the brilliant sodium flame. In less than a quarter of an hour the purified metal solidified in the converter bottom. It was upset on the hearth and the pasty slags separated. They were opaque and dull, only ½ cwt. of slag could be separated. The refined metal weighed 639 kilos. (1,405 lbs.), which, when compared with the 725 kilos. charged, would give a total waste of 12 per cent.; but in reality the waste is less, for one should add to the metal weighed the splashes of metal thrown by the ebullition against the lining of the converter, and which are only removed every two or three days. Reckoning them in, the actual waste is reduced to 7 or 8 per cent., but it would be necessary to take the mean of many conversions to be exact. At any rate the analysis of the slag proves that the iron is very little oxidized.

Second conversion: The converter was charged with nitrate of soda, 138 lbs., or 8½ per cent.; quartzose sand, 20 lbs.

The molten metal was not hot enough—the reaction sluggish. The gases at the top of the funnel did not catch fire; the vapors, at first white, then gray, then black, ended with being white. The whole operation lasted 4½ minutes. Nevertheless, the refined metal seemed as fluid as on the first occasion, and presented a similar appearance. It was not weighed. The slag, too, was like that of the first conversion. It weighed 51 lbs.

Third operation: The converter was charged with nitrate of soda, 130 lbs., viz., 8 per 100, quartzose sand, 20 lbs. The molten metal was far too cold, and for 5 minutes there was no reaction. It must have solidified in the perforations of the plate. To start the reaction it was necessary to break the plate by the thrusts of an iron crowbar, worked through the box-funnel of the converter. Even then the reaction was slow, for it lasted six minutes, *i.e.*, 11 minutes altogether from the time the metal was run in. The vapors were very black, neither flame nor nitrous gas was seen to issue from the chimney; nevertheless, the temperature developed was sufficiently high to keep the metal entirely fluid. In the end the conversion succeeded as before, yet one cannot but think that the homogeneity of the product must have been impaired by the low initial temperature. The metal and the slag both resembled the products of the proceeding conversions. The slag weighed 77 lbs. The metal itself was not weighed.

Fourth operation: There was charged into the crucible, nitrate 113½ lbs., viz., about 7 per 100, quartzose sand, 16 lbs. The molten metal was hot. Flames appeared from the first at the base of the converter, and at the end of 2 minutes at the top of the chimney. The whole operation only lasted 3 minutes. As in the preceding experiments, the vapors were hardly at all nitrous. They were very black till the flame appeared. Mr. Heaton considered that this conversion was in all respects normal. The metal and the slag were still the same as in the preceding conversions. Nevertheless, the purification was less complete; the metal, however, was flattened under the hammer at a dull red heat without breaking. Water thrown upon the incandescent metal emitted the odor of sulphuretted hydrogen. As the waste cannot be deduced from any isolated conversion, weighing the metal and the slag was given up.

EXPERIMENTS ON HAYANGES PIG.

The Hayanges pig was treated like the Longwy pig, only that the charge of nitrate was increased. The proportion of sand was also augmented; in reality, as

we shall see, it ought to have been entirely suppressed on account of the 3 per cent. of silicon in the pig. This high percentage of silicon shows itself by a greater intensity of action, and by the increased temperature of the metal. The ebullition and the projections were more violent. The red nitrous fumes were no longer masked by the black smoke. The slag was more abundant and more silicious, and for that reason less rich in phosphoric acid. The purification was less perfect, and one could already see that the dephosphorization is in general less complete in the presence of an excess of silicon, or at any rate that it would be necessary to use a much stronger dose of the nitrate to attain the same result. To calculate the weight of metal converted, I will assume, as before, a waste of 7 per cent. in remelting; and, further, 72 lbs. per conversion must also be deducted for the weight of metal found in the cupola at the end of the day's work.

Fifth operation: The cupola was charged with 1,626 lbs., which, allowing for the 7 per cent. of waste, gives 685 kilos. There are 72 lbs. more to deduct for the residue found in the cupola.

There remains, then, 652.4 kilos., equal to 12 cwt. 3 qr. 10 lbs.; to which must be added for the perforated plate, 54.4 kilos., equal to 1 cwt. 8 lbs.; pig metal and sound iron bars, 5.4 kilos., equal to 19 lbs. There was charged into the nitrate chamber: nitrate, 148 lbs., viz., 9.4 per cent.; quartz sand, 23 lbs.

The molten metal ran hot into the converter, and the reaction took place at once. A great volume of yellow vapor was emitted; in one minute the smoke became black, thirty seconds afterwards it took fire; the light was brilliant and of a bright yellow, the roar intense. That lasted thirty seconds, then the flames went out, the vapors became white and rapidly decreased; all was over in two minutes. The mass of metal was extremely hot and fluid, the nitrate chamber was not detached for thirty minutes; nevertheless, both metal and slag were still fluid. The slag could be drawn out like glass into thin threads of a fine emerald green; small sparks of iron in combustion, such as are produced when cast-steel is run into ingot moulds, disengaged themselves from the metal with jets of yellow flame; the refined metal was not entirely solidified till an hour after the metal had been run into the converter. Thanks to the great heat developed, the two wrought-iron bars which lay on the perforated plate had entirely disappeared, while in the experiments on Longwy pig some portion of them had always been found simply incrusted in the mass of refined metal. This operation produced: Refined metal, 1348 lb.; splashes of metal in the converter, 80 lbs.; total, 1,428 lbs. The waste was, consequently, 1.9 per cent. of pig converted. The slags weighed 253 lbs. They were vitreous when broken, showing a conchoidal fracture, and black in bulk, but of a fine dark-green color in thin chips. They contained globules of metal. The refined metal was vesicular, silvery white, as usual; but its hardness and its crystalline appearance denoted an insufficient dose of the oxidizing agent, which subsequent analysis has confirmed. It was for this reason that the proportion of nitrate was increased in the following experiments:

Sixth conversion: There was charged into the converter: Remelted pig, 1,438 lbs.; perforated plate, 120 lbs.; total of pig, 1,558 lbs.; wrought iron bars, 12 lbs.; total, 1,570 lbs. The nitrate chamber was charged with: nitrate, 170 lbs., or 77 kilos., viz., 10.8 per cent.; quartzose sand, 21 lbs., or 9 kilos. The molten metal came out of the cupola at a low temperature in consequence of an accident to the fan blast. The action was at first imperceptible. There was but a slight emission of white vapor, resulting, no doubt, from the moisture of the nitrate. At the end of one and three-quarter minutes, however, there was a faint exhibition of nitrous fumes. In two and three-quarter minutes the gases kindled in the converter itself, but the flames did not reach the top of the chimney; the nitrous fumes were still perceptible. At three and a quarter minutes these yellow fumes were still stronger; there was an intense roar. In four and a quarter minutes the slag was projected through the box-funnel of the converter, and the ebullition was violent. The flame in the converter went out, and at the same moment the yellow smoke became black. In four and three-quarter minutes the vapors became first lighter in color. then white. In five minutes all was over. In spite of the relative slowness of the conversion, the heat

developed seemed as great as in the first experiment. The metal was hot; it took an hour for the mass to solidify, and, as usual, it gave out jets of yellow flame. The slag was "thready," and just like that of the preceding conversion; it weighed 255 lbs. The weight of refined metal was 1,475 lbs.; the splashes adhering to the lining of the converter, 80 lbs.; total 1,553 lbs., or 703.5 kilos. The waste would, consequently, appear to be only 7.6 kilos., or less than 1.1 per cent.—a result which is evidently wrong.

The splashes attached to the interior of the converter could not have been evenly distributed among the three conversions, or the crane ladle must have been fuller than usual. The actual waste, as I have said before, can only be calculated from the mean of many conversions and from the chemical analysis of the slag.

Seventh conversion: The charge, as in the previous conversion, was: pig-iron, 705. kilos., equal to 13 cwt. 3 qr. 14 lbs.; wrought-iron, 5.4 kilos., equal to 12 lbs.; nitrate, 200 lbs., equal to 96.6 kilos. (12.7 per cent.); sand 24 lbs., equal to 10.3 kilos. The molten metal was hotter than on the second conversion, not so hot as in the first. The phenomena I noted were as follows: abundant nitrous fumes appeared from the very first, but presently slackened. In one and a quarter minutes there was a lively emission of yellow gases and strong projections of slag and metal through the box funnel of the converter. In two and a quarter minutes the gases kindled at the top of the chimney. The flame lasted half a minute, all was over in three minutes. The metal was very hot, very fluid. The slag as before. It weighed 210 lbs. The converted metal was not weighed.

Eighth conversion: The charge the same as in the last, to wit— pig and iron, 711.1 kilos., equal to 13 cwt. 3 qr. 27 lbs.; nitrate, 90.6 kilos., equal to 1 cwt. 86 lbs.; sand, 10.9 kilos., equal to 23 lbs. The molten metal ran out moderately hot. There was little difference in the progress of this conversion and the last. Nitrous fumes were disengaged at once, though faintly at first. In one minute there was a partial combustion of gases in the interior; there were some projections, and the smoke soon became black. In one and a half minutes the smoke kindled at the top of the chimney, there was a deafening roar, abundant projections, and the flames exceedingly brilliant. In two and a half minutes all was over. Then, as usual, there was nothing more visible but a faint white vapor.

The metal remained a long time fluid. It was still so after forty minutes, when the nitrate chamber was detached from the converter, and it was a whole hour from the commencement of the conversion before it could be turned out on the floor of the foundry. The converted metal weighed 1,458 lbs. (equal to 660 kilos.), the slag 252 lbs. (equal to 123 kilos). Consequently the waste would be 134 lbs., or 7.2 per cent. The metal and the slag looked like the products of the last conversion.

We cannot calculate the mean waste on the four conversions, not having the weight of the converted metal in the third. But, taking the weight of the first, second, and fourth, we find—pig treated, 2,134 kilos., equal to 4,694 lbs.; refined metal resulting, 2,010.5 kilos., equal to 4,222 lbs.; waste, 124.5 kilos., equal to 273 lbs.; say 6 per cent. And this, as we shall see, agrees pretty nearly with the results obtained by calculating the iron in the slags. Before we pass on to describe the conversion of the crude product into steel or iron, let us add that the Cleveland brands, of which we saw many charges treated in the Heaton converter, are to be classed between the two extremes we have been dealing with.

They are less graphitic than the Hayanges pig, but grayer than the Longwy pig. And so the reactions in the converter are also intermediate. The vapors, before they kindle, are less nitrous and less black, but they are pretty black too. The slags are more vitreous and silicious than those of Longwy; more opaque and dull than those of Hayanges. In fine, the reactions in the Heaton converter depend, above everything, as is the case in the Bessemer process, on the proportions of silicon. But the progress of the conversion depends also on the initial temperature of the molten metal, and on the degree of care which is taken in the arrangement of the nitrate chamber.

II.—CONVERSION OF THE REFINED METAL INTO WROUGHT-IRON.

The refined metal is converted into malleable iron, as I said before, by a sort

of rapid puddling, continued long enough. In the production of balls, part of the refined metal resulting from the four conversions of Longwy pig was so treated, and from three out of the four conversions of Hayanges pig. Here are the particulars of the experiments in question.

(1.) *Malleable Iron of the First Conversion* (*Longwy Pig*).—A charge of 392 lbs. (177.5 kilos.) was converted in less than three-quarters of an hour into four balls, one of which was hammered into blooms, and three others hammered and rolled into flat rough bars. Their total weight was 312 lbs., so the waste was 79 lbs., or 20 per cent. A second similar charge gave five rough bars, with a waste of 20½ per cent. A bloom from the first charge was reheated to a welding heat, then rolled into flat merchant bars of 3 in. by ⅜ in. (No. 1.)

The three rough bars of the first charge were cut up, faggoted, piled, and rolled into merchant bars of 2 in. by ⅜ in. (No. 2.)

The five rough bars of the second charge were likewise cut up, faggoted, and piled; but these were rolled into small bridge rails, of which the transverse section was about 2 in. (No. 3.)

The waste in the piling was not determined, but we may take it to be the usual average—say 10 per cent.

I will presently give the result of the tests to which these bars were submitted. At present I will only observe that the bars of the first charge were evidently over-puddled. The fracture, lamellar and foliated, shows burnt iron. The rail, after being nicked, broke at the first blow. Its being over-oxidized was at the time attributed—wrongly as we shall see—to an overdose of nitrate. This is why the charge of nitrate was diminished in the subsequent conversions. The rough bars were cracked in the edges.

(2.) *Malleable Iron of the Second Conversion of Longwy pig.*—A first charge of 259 lbs. was treated in 30 min. Each hammered bloom was returned to the furnace for 5 min., and then hammered a second time, then reheated to a white heat—they were rolled into bridge rails like the former. (No. 7.) The rails are clean, without cracks, and when cold bear without fracture repeated blows of the sledge. One of them, hammered till it broke, did not give way till its two halves were brought to an angle of 75 deg. The fracture was fibrous, but the fibres were rather short.

A second charge of the same weight was heated in 25 min. It was then hammered and rolled into rough plate, which showed more cracks than the bars of the first conversion. The rough iron so produced was cut up, faggoted, piled, and rolled into bridge rails. (No. 4.) One of these rails, tested, till it gave away, by the sledge, did not break till its two ends were brought to an angle of 75 deg. The fracture was fibrous, but the fibres were rather short.

A second charge of the same weight was treated in 25 min. It was then hammered and rolled into rough plate, which showed more cracks than the bars of the first conversion.

The rough iron so produced was cut up, faggoted, piled, and rolled into bridge rails (No. 4.) One of these rails, tested till it gave way by the sledge, did not break till its two ends were bent double.

(3.) *Malleable Iron of the Third and Fourth Conversions of Longwy Pig.*—Part of the refined metal of the third and fourth conversions was converted into bridge rails after the manner of the last-mentioned charge (5 and 6). The rails so obtained by ordinary faggoting and piling were like the piled rails of the second conversion, but their fractures were less fibrous. The refining did not seem thorough; the fractures showed a certain lack of homogeneity.

(4.) *Malleable Iron of the Fifth Conversion* (*Hayanges Pig*).—257 lbs. of refined metal of the fifth conversion was treated in the puddling furnace. Part of it was made into two blooms, which were reheated to a white welding heat, then rolled into bridge rails. They showed some cracks, which were sure proof of incomplete purification. Part of it was treated in the usual way—the rough bars were cut up, faggoted, piled, and rolled into flat bars of 2 in. by ⅜ in. (No. 8.)

(5.) *Malleable Iron of the Sixth and Eighth Conversions* (*Hayanges*).—Some cwts. of the refined metal of the sixth and eighth conversions were treated in the same way. By faggoting and piling, some flat rolled bars were produced of 2 in. by ⅜ in. (Nos. 9 and 10), and some square hammered bars of ½ in. square (No. 12).

Two bars of the eighth conversion were

also hammered into blooms, and reheated to a white welding heat without piling. After this reheating one of them was drawn out under the hammer into ½ in. square bars (No. 13); another rolled into flat bars of 2 in. by ⅜ in. (No. 11). I pass rapidly over these details because, as I have already said, I do not think the Heaton metal can profitably be worked up into malleable iron. The nitrate purification is too costly, and the waste in balling and blooming too great.

Besides, the quality of the iron produced was not all that could be desired: but at the same time it must be remembered that in these experiments the percentage of nitrate used was, to some extent, settled at hap-hazard, and in every instance without any preliminary analysis of the pigs, and moreover the puddlers knew nothing of of the material they were dealing with. The tenacity of the bars was roughly tested by their resistance to the blows of a sledge, as before stated, but was more accurately determined at Mr. Kirkaldy's well-known establishment in London.

III. BREAKING TESTS OF THE IRON.

The iron bars were all tested just as they arrived from the works. The length submitted to tension was 10 in. I sum up the results in the following Table, which contains, besides the English figures, a column showing the breaking strain in kilos. to each square millimetre of the original section. The numbers of the experiments correspond to the figures in brackets which follow the account of each conversion.

Table of the Tension Tests of the Malleable Irons made from the Longwy and Hyanges Brands, compiled from Mr. Kirkaldy's Tables.

Description of Bars.	Dimensions in inches.	Original section of bars in square inches.	Breaking strain. (Original area). Tons per square inch.	Breaking strain. (Original area). Kilos per millimetre sq.	Comparison of the area of fracture with original area.	Percentage of elongation.	Observations.
No. 1. Longwy flat bars, not piled. Mean of six bars from the first conversion.............	3×⅜	1.125	18.7	29.4		7.0	Fibrous fracture.
" 2. Longwy flat bars, piled.........	2×⅜	0.768	19.3	30.4		7.4	Ditto.
" 3. Longwy, conversion No. 1, bridge rail................	"	2.08	19.3	30.4		9.0	No. 3 to 6, experiments on a single rail; all four rails rolled from the crude iron piled. Fracture, half fibrous, half crystalline.
" 4. Longwy, conversion No. 2......	"	2.08	19.9	31.3		10.8	
" 5. Longwy, bridge rail, conversion No. 3....................	"	2.08	19.0	29.9	Not determined.	8.6	
" 6. Longwy, bridge rail, conversion No. 4....................	"	2.08	19.6	30.8		10.6	
" 7. Bridge rail of conversion No. 2, rolled, not piled...........	"	2.08	18.8	29.6		7.1	Half fibrous, half crystalline.
" 8. Flat bars, piled, Hayanges, conversion No. 5. Mean of four bars......................	"	0.768	21.1	33.2	0.84	10.1	Fibrous.
" 9. Flat bars, piled, Hayanges, conversion No. 6. Mean of four bars	"	0.768	22.2	34.9	0.77	15.3	"
" 10. Flat bars, Hayanges, No. 8, piled. Mean of four bars....	"	0.713	20.5	32.3	0.85	12.3	"
" 11. Flat bars, not piled, Hayanges, conversion No. 8...........	"	0.768	21.6	34.0	0.86	6.1	"
" 12. Square bars, Hayanges, conversion No. 8, piled and tilted. Mean of four bars..........	½×½	0.278	23.1	36.4	0.77	13.9	"
" 13. Square bars, but not piled. Mean of four bars..........	"	0.278	27.5	43.3	0.81	10.8	Half fibrous, half crystalline.

What are we to conclude from this Table? If we only took into consideration the breaking strain (*i. e.*, the statical breaking strain), we might say that the strength of the Longwy malleable irons, prepared by nitrate, was about the same as that of common iron of equal dimensions; and that the bars Nos. 12 and 13 approximate even to high-class irons. But this datum does not in itself suffice to determine the value of a metal for the work it is called upon to sustain. Harsh and brittle irons are equal, if not superior, to the best soft irons in this respect. It is their dynamic resistance which we must attend to; that is to say, the "work" of the bars submitted to strains within their elastic limits. In default of these data, which are wanting, we should at any rate arrive at a more precise criterion of the value of the iron, compare the elongation and the breaking load, or, as Mr. Kirkaldy proposes, compare this load, not with the original section, but with the section at the fracture.*

From the numerous experiments tabulated by Mr. Kirkaldy, we may arrive at the results embodied in the following Table:—

Bar Fronts.	Breaking Strain (Fractured area).		Breaking Strain (Original area).	
	Kilos. per mill-sq.	Tons per square inch.	Kilos. per mm. sq.	Tons per square inch.
Swedish malleable iron, Ekman & Gothenburg†	100 to 112	54 to 67	33 to 35	21
‡Fagersta homogeneous iron for fine wire......	125 to 141	83 to	32 to 38	22
Lowmoor iron............................	90 to 100	51 to 58	40 to 45	25 to 29
Staffordshire best........................	80 to 88	42 to 45	41 to 43	25 to 28
Scotch B. B.............................	60 to 70	35 to 40	42 to 46	26 to 29
Scotch common...........................	50	24	42	26

On comparing the figures of these two columns, we see that by the first, Swedish malleable iron quite heads the list, while by the second it would be classed below even the common Scotch. We see also that by the figures in the second column, the justly celebrated Lowmoor iron would be no better than the common Scotch. To determine the value of the irons, we must, therefore, above all, consider the breaking strain with reference to the area of fracture. Well, if we calculate the breaking strains of the Moselle flat bars, of which we know the areas of fracture, we shall arrive at the following figures:

Nos. of the bars.	Breaking Strain. Kilos. per sq. millimetre.	Tons per sq. in. (Area of fracture).
No. 8, of the 5th conversion.......	39.8	25
" 9, " 6th "	43.3	27
" 10, " 8th "	37.9	20
" 11, " 8th "	39.6	25
" 12, square piled bars of the 8th.	47.3	29
" 13, square bars of the 8th, not piled	53.2	34

Comparing these results with the preceding ones, we see that the Hayanges irons, prepared by the nitrate process, may be classed with the ordinary Scotch irons. The same conclusion may be deduced from the "elongation" column. Swedish iron and good English irons elongate, before fracture, to the extent of from 25 to 30 per cent. of their original length, while the elongation of the common Scotch iron does not exceed 10 or 12 per cent., and is sometimes as little as 6 or 7 per cent., which, according to the Table on page 32, is about the average elongation of the Moselle irons, ranging from 6 to 15 per cent. These irons are consequently of "ordinary quality." They are soft and elongate but little under tension—more especially the Longwy irons, whose elongation is even less than those of Hayanges. Ought we to attribute this inferiority of the Longwy irons, and, in general, the medium quality of these nitrate-treated irons, to the inefficiency of the new refining process? I think not. We have

* Mr. Edwin Clark, in his work on the "Britannia and Conway Tubes," has shown that a bad boiler-plate, very brittle and crystalline, can stand 22 tons to the square inch, but without any elongation, while on a mean, good boiler-plates will only stand 19 tons, but with elongations which vary from 5 to 12½ per cent.

† Swedish malleable iron contracts before breaking in the proportion of 100 to 30 and 25. Lowmoor iron in the proportion of 100 to 47, and common Scotch iron in the proportion of 100 to 85.

‡ Fagersta figures extracted from Mr. Hewitt's report.

already seen that in the case of the Longwy iron, the puddling or reheating was badly done. The irons were burnt. The decarburization was carried too far, as we shall see. Besides, the fracture of the bars denotes an iron which is hardly homogeneous; we see specks dark-colored and dull, which show that the slags are not sufficiently expelled. The heats have been insufficient, and the gases of the furnace too oxidizing.

Mr. Kirkaldy's table of experiments on the nitrate-treated Moselle irons prove, too, that piling has effected no improvement. Further, if bars Nos. 12 and 13 show more tenacity than the rest, this is attributable to their smaller size and to their having been hammered. We know that hammered irons are stronger than rolled irons, and that their strength increases in inverse ratio to the section of the bars.

IV. CONVERSION OF THE REFINED METAL INTO CAST-STEEL.

Cast-steel has been hitherto made at Langley Mill, as we before said, by simple reaction in the crucible. The crude metal is hammered, at a low red heat, into thin discs, called "cake," which are broken up and classed according to the grain, like cemented steel, into numbers indicating their degree of hardness. These cakes are mixed in the crucible with more or less malleable iron and spiegeleisen, according to the product it is desired to obtain. The malleable iron regulates the degree of hardness; the spiegeleisen, by its manganese, finishes the refining process. A part of the metal refined in the seven last conversions was thus treated. Here are the details of the operations: Steel of the second conversion of Longwy pig. Two crucibles were charged, each with 33 lbs. of converted metal in cakes, and 12 lbs. of malleable iron from the first conversion; spiegeleisen of Siegen, three-quarters of a pound. Each crucible produced an hexagonal ingot of 2¼ in. in diameter. The melting took four hours. The steel was very fluid, and showed little tendency to rise. The fracture of the ingot showed large grains, and indicated soft steel, which agrees with my analysis of the carbon, which, according to the Table I shall presently give, will be seen not to exceed 0.0036. The ingots were tilted under the hammer at a low red heat, without showing any cracks. The grain of the tilted bars was fine, homogeneous, light gray, but rather shiny. The skin was quite smooth. Six ½ in. square bars were sent to London to be tested by tension at Mr. Kirkaldy's. Other bars were sent to Longwy to be tested as tools under the eyes of MM. d'Adelsward. Cutting tools, turning tools, and cold chisels were made out of them. When tempered in the ordinary way, the edges of the cutting tools give; when highly tempered, the tool stands, but the cold chisels have a tendency to chip under concussion. It is not high-class steel; it is not thoroughly purified. A pure steel, containing only 0.0036 of carbon, would not temper. If it tempers, notwithstanding this low percentage of carbon, it is because it contains other ingredients. We shall find in it silicon and phosphorus as well as carbon. Yet, as common Bessemer steel contains also foreign ingredients, it is not impossible but that it may be useful for rails and plate iron. It only gives way under a tension strain of 49.5 tons per square inch, with an elongation of 12.5 per cent.

II. STEEL FROM THE THIRD CONVERSION OF LONGWY PIG.

The crucibles received the same charge as before, and an ingot was run from each crucible. The grain was finer, closer, the blow-holes less numerous. The steel was, in fact, more carburized (0.0055 carbon instead of 0.0036). When too highly heated, it showed symptoms of cracks, but sound bars of ½ in. square were readily obtained, and when made into tools, gave results very similar to those obtained from the second conversion. Their tenacity, however, was greater—viz., 52 tons instead of 49 tons per square inch, as was to be expected from their higher degree of carburization. But the bars elongated less before giving way, and this indicates a certain degree of shortness, certainly attributable to foreign ingredients. The elongation is reduced to 4 per cent.

III. — STEEL OF THE FOURTH CONVERSION OF LONGWY PIG.

There was charged into the crucibles: Refined metal in cakes 30 lbs.; malleable iron from the first conversion, 15 lbs.; spiegeleisen, ½ lb. The ingots resembled the steels of the second conversion. In spite of the smaller percentage of nitrate,

the percentage of carbon was the same (0.0033 to 0.0036), in consequence of a larger proportion of malleable iron having been used in the crucible. But the purification was less advanced, the steel less pure. The breaking strain, indeed, is little less than that of No. 2, but the diminished elongation (only 6 per cent. instead of 12.5 per 100) shows the presence of foreign elements. The tools blunted when slightly tempered, chipped when highly tempered. This experiment, when compared with the results of the second conversion, proved that to obtain sound steel, it would be better to increase the charge of nitrate in the converter so as to purify more thoroughly, and the charge of malleable iron in the crucible unless we were to recarburize the metal, as in the Bessemer converter, by a larger addition of good spiegeleisen.

We should also remark that the ingot of the fourth conversion is no more "true steel" than that of the second; at any rate, it is not carburized steel, for 0.0035 to .0036 of carbon is not sufficient to convert iron into steel. It is homogeneous iron, which hardens in water, thanks to the silicon and phosphorus it retains; but this impure iron, slightly carburized, has less body than true steel. It resists slow tension, but yields to a sudden shock, and elongates but little.

IV.—STEEL OF THE FIFTH CONVERSION OF HAYANGES PIG.

There was charged into the crucible: Refined metal in cakes, 34 lbs.; malleable iron made from the refined metal of the same conversion, 14 lbs.; spiegeleisen ½ lb. The ingots on fracture denoted by their large grains a steel containing little carbon. They forged easily at a low red heat, but some few cracks were visible at the first heating. To obtain a steel more free from foreign ingredients, charges of the following composition were melted in five crucibles:—Cakes, 30 lbs.; malleable iron, 14 lbs.; spiegeleisen, ½ lb.

The 5 charges were run into a single mould for an ingot of 2 cwt.. This large ingot was to be rolled into rails at Hayanges. It was sent, but the trial did not take place in consequence of the rolling mills not being adapted for rolling steel. The small ingots from the two first crucibles were tilted into ½ in. bars, and tested by tension at Mr. Kirkaldy's. The mean of the four bars showed a breaking strain of 80 kilos. per millimetre sq. (51 tons per sq. in.), but the elongation was only 3.1 per cent. The metal was shorter than that of the preceding bars. Its percentage of carbon is 0.0037. It is therefore not true steel, but homogeneous iron, more or less hardened by its phosphorus and silicon. The tools made at Hayanges from the first ingots blunted on hard pig, even when hard tempered. So in the matter of hardening in water, as in the matter of dynamic resistance, phosphorus is but an imperfect substitute for carbon.

V.—STEEL OF THE SIXTH CONVERSION OF HAYANGES PIG.

Two ingots were made as follows: refined metal, 34 lbs.; malleable iron of the the same charge, 14 lbs,; spiegeleisen, ¼ lb.

The fracture of the ingots showed a metal very slightly carburized. The tilted steel only retained .0032 of carbon. When hot the metal worked easily, and it was tilted without cracks; but the cutting tools made of it blunt more easily than those of the fifth conversion. It is therefore simply homogeneous iron, hardened by phosphorus, not steel. Some bars of ¾ in. sq. were tested by the tension strain. The mean of four bars was 59.3 kilos. per sq. millimetre (37.8 tons per sq. in.), with an elongation of 1.3 per cent. That is less than the bars of the fifth conversion, in spite of the increased charge of nitrate; but here the difference arises chiefly from the larger dimensions of the bars. Their transverse section is twice as large. A third ingot of 2 cwt. was run from the united charges of five crucibles, made up as follows: cakes, 30 lbs.; malleable iron, 15 lbs.; spiegeleisen, ½ lb. This large ingot, like its predecessor, was to be rolled into rails, but this has not been done, for the reason above given.

VI.—PRODUCTS OF THE SEVENTH CONVERSION OF HAYANGES PIG.

The refined metal of the seventh conversion was to be treated in Mr. Heaton's own patent furnace, but it was entirely scorified by the injudicious arrangement of the furnace.

VII.—STEEL OF THE EIGHTH CONVERSION (HAYANGES PIG).

Eight crucibles were charged with: cakes, 30 lbs.; malleable iron of the same

conversion, 15 lbs.; spiegel, ½ lb. The fractures of the ingots were finer-grained than before; the steel forged easily. Turning tools and cutters made of it stand fairly when moderately tempered, but chip if over-tempered, and blunt if insufficiently tempered. This was the most highly carburized of the three steels made of Hayanges pig. I found it to contain .0048 of carbon, and even .0062 in the ingot. That is the line of demarcation between steel and hard iron.

The experiments as to breaking strain on four ½ in. square bars gave about the same results as the sixth conversion. They broke under a mean load of 79.2 kilos. per sq. millimetre (50.3 tons per sq. in.), with an elongation of 3.2 per 100. That is still a steel, or hard homogeneous iron, lacking "body." We see that the Hayanges steels elongate less than those of Longwy. Now their analyses clearly prove, as we shall see, that this is due to their larger percentage of phosphorus, and that, *cæteris paribus*, the dephosphorization is the less complete as the pigs are the more silicious.

(TO BE CONTINUED.)

IRON AND STEEL NOTES.

STEEL RAILS.—At the recent meeting of the Iron Steel Institute, held at Middleboro', some valuable and practical information was given on the subject of the manufacture of steel and its adaptation to rails. Mr. Edward Williams said that it has been too much the habit to assume that there is antagonism between those who make rails and those who use them, and that the former desire only to make cheap rails, however bad, and that the latter interpose difficulties and onerous stipulations without reasonable cause. He believes this view to be entirely incorrect, and that, on the contrary, the great majority of engineers and ironmakers alike are, in their several ways, striving after the same end—namely, rails of high quality at the lowest price possible. The rails of to-day are of two distinct kinds—those made from ingots and those built up; and he admits that, the question of cost and possible supply not considered, ingot made rails are the best. He holds it incorrect to describe the two kinds as steel rails and iron rails, because the Bessemer rails now making have a percentage of carbon much lower than that of steel proper, as it used to be known. Besides, as far as he knows, it is impossible to define where iron ends and steel begins. It would be as well, therefore, to call the two divisions ingot rails and piled rails. He has come to the conclusion, unwillingly, that they could not succeed in producing puddled, workable, and welded solid blooms; and as far as present knowledge extends, ingots cheap enough to make rails on a considerable scale are only to be obtained by the Bessemer process. Whether or not the Siemens-Martin process can compete in point of cheapness of production with the Bessemer process is as yet unproved; but it is sufficient to know that both can without doubt produce ingots that roll into rails without much difficulty; and that such rails, being free from the possibility of lamination, must be more enduring than built-up or piled rails, however carefully made. If the phosphorus difficulty can be got over—and Mr. Williams thinks it can—and if the cheap pigs of the Cleveland district were available for the Bessemer process, there would be so great a reduction of cost that ingot rails would be almost as cheap as piled rails, and the latter must at once give way; but there is not at present any good ground for expecting that such a change is near. The removal in February next of the bulk of the present Bessemer royalty charge will no doubt reduce the selling prices of ingot rails; but the author of the paper was mistaken if, after all, they could be produced so as to be sold within 40s. or 50s. per cent. of the average selling price of good piled rails, the life of which in the ordinary operations of a heavily worked railway would be about 15 years. For very severely worked places ingot rails, at almost any moderate extra price, were of course the best. Strenuous efforts had been made by nearly all the great iron makers to produce steel-topped rails, which, it was hoped, would be made much more lasting than the usual piled iron rails, and less costly than ingot rails. Puddled steel seemed to offer a cheap and good material for this; and after some difficulty to begin with, it was produced of very uniform quality. It was no doubt a material capable of resisting well the wear and tear of railway stock; but it could scarcely be welded at all, and as it could not be obtained in solid blooms for rail sizes, the system failed, and had been abandoned—in this country at least—entirely. That Bessemer steel slabs could by great care and skill be so fastened to iron as to make rails was proved by the instance of the rails supplied to the Edinburgh and Glasgow Railway, and to the Swedish Government. He, however, did not expect to find such rails come into general use, because of the difficulty of welding in the steel slab, which was not much, if at all, less than puddled steel. So far as he could see, the only choice lay between the ingot and the piled rail, and in the uncertainty as to the Siemens-Martin process, it might be assumed that the Bessemer process would supply the former. He did not advocate the discontinuance of the system of testing rails. But to meet the severe tests, it was absolutely necessary to use fibrous iron, and not to heat it too much. He had thought and experimented much upon the subject, and was satisfied that fibrous nature and weldability did not go together, and that only well-piled crystalline iron welded easily, and therefore with moderate certainty. It was undesirable, he thought, to use rail piles of great sectional area, which were less likely to be tested equally at the centre than the small piles of a quarter of a century ago. The two great rail-producing districts of this country were Wales and the North of England, and each had a system of working different from the other. The Welsh system had the merit of more work on the iron—that is greater consolidation—than was obtained by the North of England system. That was a doubtful advantage, if it was true, as he believed, that the iron for rails was, as a rule, too much worked, while it had the demerit of having

many through welds on the heads of the rails. The North of England system produced hard crystalline heads, with the fewest possible welds; and when the iron of the district was not too much worked, and thus made fibrous, it was of the most weldable character, though somewhat brittle. Such iron, it seemed to him, was likely to produce enduring rails, and he firmly beleived that, with proper attention, piled rails could and would for a long time yet be made from it, capable of competing successfully with good ingot rails produced by the Bessemer process.—*The Railway News.*

Manufacture of Iron and Steel by the Nitrate Process.—Mr. J. P. Budd, of Ystalyfera, near Swansea, has recently patented an invention which has for its object to subject molten cast-iron to the action of nitrate of soda and soft hematite iron ore or other oxide of iron, previous to its being subjected to the puddling process. For this purpose he runs the molten cast-iron into shallow pans capable of holding from 3 in. to 5 in. in depth of melted metal and lined with a paste composed of the above-mentioned materials. When the fluid metal is poured into the pans a violent ebullition takes place, and a large proportion of the silica, together with some of the carbon, phosphorus, and sulphur contained in the iron, is carried off in the slag, so that when the slabs of purified metal are subsequently worked in the puddling furnace, the puddling operations are effected much more rapidly than with ordinary pig iron, as when puddling ordinary pig iron in a puddling furnace but a very small proportion of carbon is separated from the iron before the greater proportion of the silica is eliminated. Cast-iron, if of a suitable quality for steel making, may advantageously be acted on by a paste containing nitrate of soda or hematite ore, or both combined, in shallow pans, as above described, previously to being decarbonized to convert it into steel.

When the object is to produce bars of wrought iron which are to be rolled into black plate or thin sheet iron, to be afterwards converted into tin plate, Mr. Budd lines the shallow pans into which the cast iron is run with a composition composed of hematite iron ore and nitrate of soda. He mixes together a quantity of hematite iron ore, containing, if possible, no phosphorus or sulphur, and only a moderate quantity of silica, and mixes therewith half by bulk or two-fifths by weight of nitrate of soda, or 30 lbs. of hematite ore to 20 lbs. of nitrate of soda. Having well mixed these together mechanically, the mixture is passed through a pair of clay rolls, by which the grit is reduced, and it becomes more plastic. A paste is then formed of the mixture which requires about three-tenths of its weight of water to be added; it is then sufficiently liquid to be filled into a bucket. A series of shallow moulds of cast-iron are then placed as near as convenient to the tapping hole of the blast furnace from which the fluid cast iron is to be obtained. Those found convenient are of the following dimensions:—Length, 7 ft. 9 in. at top tapering to 7 ft. 4½ in. at bottom; width. 2 ft. 2 in. at top tapering to 1 ft. 9½ in. at bottom; depth, 4 in. The use of the bevelling or tapering in the mould is, that the plate of cast-iron shall be more easily removed from it. These moulds hold about 13 cwt. of cast-iron when filled about 3½ in. deep. Into these moulds molten cast-iron is run every 4 hours or oftener, care being taken to fill them often enough that they shall retain their heat or drying power between the casts.

As the casts from the furnace must thus be frequent the iron is potted from the furnace—that is, the operator takes out what iron he requires from an opening into the furnace at the upper part of the tapping hole without emptying the whole of the iron in the half. Whilst the moulds are hot from the previous cast he pours into each of them a bucketful, or about 64 lbs., of the refining mixture before described, and spreads it evenly over the bottom and sides. The water evaporates, and the mixture lies at the bottom as an adhering paste. The workman then proceeds to run the molten iron from the furnace until he has filled the moulds about 3½ in. A great ebullition takes place, fumes in large quantity are evolved, jets of flame burn from the surface of the metal for a considerable time, a quantity of scoria is thrown up violently to the surface and separates from the plate of iron that fills the mould, and when cold can be stripped therefrom. The weight of the scoria so thrown up is from 30 lbs. to 40 lbs. from each plate of metal weighing about 13 cwt. The iron contained in the hematite ore used in the paste is converted into cast-iron, and adheres to the bottom of the plate. The refined iron when broken presents a honeycomb or cellular appearance throughout, and resembles overblown refined metal, and a large proportion of the silica will have been removed from it. The iron thus refined is ready for the puddling process.

As advanced refined metal Mr. Budd finds it advantageous to use some pig iron with the iron refined as above in puddling; about one-third of pig iron answers best. Cast-iron thus refined, even if it be what is commercially known as cinder pig, which is produced when iron scoria are largely used as material in the blast furnace, will make excellent puddle bars and work to a good yield. The process of puddling is shortened, and the sides and the bottom of the furnace are less acted on than with unrefined iron. The quantity and proportions of the refining paste which we have given are suitable for the quality of cast-iron known as white iron. When grey or carburetted iron is used the quantity of nitrate of soda to be used with the hematite ore should be increased; about 30 lbs. of nitrate of soda (instead of 20 lbs. as in the composition first mentioned) being used with 30 lbs. of hematite ore.

When the malleable iron sought to be made in the puddling furnace is not to be of the quality suitable for tin bars and similar purposes, but is required to be a softer working quality suitable for rails and merchant oars, Mr. Budd does not use nitrate of soda in the refining paste, but makes it of hematite ore alone. When used alone a great ebullition takes place when the molten iron runs over it, the oxide of iron in the hematite is reduced. jets of white flame burn on the surface for a considerable time, and a large proportion of the silica is separated from the iron. The refined iron in this state is much preferred by the puddlers, as it lessens and helps their work. In place of hematita ore other oxide of iron which can similarly be formed into a paste may be employed in place thereof, as, for example, the refuse of iron pyrites from which the sulphur has been extracted for the manufacture of sulphuric acid, and from which the copper and other metals contained in it have been extracted. Oxide of manganese, iron scale, or other substances capable of yielding oxygen

when exposed to heat may be incorporated with the paste.—*Mechanics' Magazine.*

Steel-making in Pittsburgh.—The manufacturers of Pittsburgh claim the credit of supplying 65 per cent. of all the various grades of steel turned out in the United States. The first essays at its production date 40 years back, but according to the "Pittsburgh Commercial" it is within the last 8 years that the most remarkable progress has been made, which has placed the steel produced there on an equality with the best imported. According to the census of 1860, the six establishments employed in this manufacture, which then existed at Pittsburgh, represented capital amounting to $1,080,000, and their annual products were valued at $888,000, a sum less than the annual sales of a single establishment at the present time. These steel works are now eight in number, and represent an invested capital of $4,500,000, and their annual products amount to nearly as much. According to the assessor's books the sales for the past year have reached the value of $3,956,845, and these being effected during a period of depression show the magnitude of the trade.—*American Railway Times.*

RAILWAY NOTES.

London to Pekin by Rail.—Let us see what is yet required in order to carry a traveller from London to Pekin. Captain Taylor, in one of his able reports, has insisted that railway travellers will never be satisfied until they can pass dry-shod from London to Calcutta. The first of the missing links is that difficulty of the channel between England and France. That we admit is rather a "big" affair, whether the work be done under or over the water. But if either of these courses should be found to present insuperable difficulties, there is the easy mode of solving the problem by providing spacious steam ferries, which would convey the passengers and luggage-vans with so much ease and comfort that the short sea passage to Calais would come to be regarded as only a portion of the railway journey. We take, therefore, a leap at once across the Channel, and find ourselves transferred from the South Eastern or Chatham and Dover systems to the Northern of France. From Calais we pass on by the existing systems of railways to Belgrade, on the Danube. The system of the Roumelian Railways which have been already planned, and which we explained very fully a few weeks since, will connect Constantinople with the other portions of the European systems of railways. From the Austrian frontier a line will be made, passing through Widin or Nissa, Sophia, Phillipoli, and Adrianople, to Constantinople. The negotiations for providing the capital for this line must sooner or later be brought to a satisfactory termination, and in the hands of a powerful body of capitalists the first stage of the journey across Europe, from Calais to Constantinople—from the Straits of Dover to the shores of the Bosphorus—will be complete. The continent of Europe is crossed—the vaster tracts of Asia now lie before us.

A line of railway through the Asiatic provinces of the Turkish Empire has already been partially surveyed. It would cover the distance between Scutari and the Persian Gulf. The Porte is willing to grant the land gratis, and it would offer to the British Government special securities for the payment of the interest and the sinking fund of the loan necessary to complete the work, if our Government would take the financial responsibility of the undertaking by guaranteeing them a loan, after the precedent of the war loan of 1855. This, no doubt, is a very serious matter. But England guaranteed for Turkey a loan to enable her to carry on the contest with Russia, the whole amount of which was expended in an unproductive outlay in a few months, leaving behind nothing which could advance the prosperity of the country. The loan so guaranteed would have made a railway from the Bosphorus to the Persian Gulf; it was spent in keeping Russia out of Constantinople, and for the purpose of securing that balance of power in Europe which at any day may be overthrown. It may come to pass that some day the statesmen who aspire to govern the world may see that promoting trade and commerce, and assisting production, and promoting the arts of peace, may be as worthy of their consideration as squandering millions in war and in the destruction of life and property. When that reform shall have taken place, the day will be near at hand when an English Government, finding that the canalization of the Isthmus of Suez has brought them into closer competition with other importing States of Europe, will find it to their interest to provide a still more direct communication with its Indian Empire; and to this end they will lend their powerful aid to that system of the Euphrates Valley Railway which has been so often and so vainly pressed upon their attention by Mr. Andrew and others. The distance from Calais to Constantinople would be by rail say 1,700 miles, thence to Bassorah, on the Persian Gulf, about 1,500 miles. From Bussorah to Bunder Abbas, along the level country of the Persian Gulf, would be about 700 miles. From Bunder Abbas to Kurrachee would be by a railway carried along the Mekran coast; the journey would be about 750 miles. The distance between Calais and Kurrachee, about 4,000 miles, would be traversed by the locomotive in 7 days.

At Kurrachee we come into connection with the system of our Indian railways. There is a connecting link required between the terminus of the Bombay and Baroda, and Kurrachee, at the mouth of the Scinde. With this completed, or the extension to Moultan finished, the Indian Peninsula would be provided for, the distance between Kurrachee and Calcutta would be accomplished, and a further 2,000 miles of railway would become available for the great overland journey. At this part of the journey we would take in hand the scheme which Captain Speye has, with so much perseverance, brought before the British public and the Government. From all that has been ascertained of the nature of the country to be traversed, there are no difficulties in the way of carrying out a system of railways through Burmah and Western China to Pekin. At present the Chinese Government are opposed to the introduction of railways. That hostility will sooner or later disappear as the people are brought more into contact with the civilization of the West. The vast population is already swarming over the United States of America. These people have rendered good service in the construction of the Great Pacific Railroad on the American continent, and the accounts which they will give on their return, or by other com-

munication, to their friends and relations in China, must have the effect of forming a public opinion in favor of the introduction of railways into China. For the present, we have our work before us to complete the missing links in Europe and Western Asia. By the time these are supplied the Chinese will be only too glad to aid in forming a portion of the Grand European and Asiatic Railway from London to Pekin.—*Railway News.*

Steel Rails and Steel-Headed Rails.—It has been too much the practice of railway managers to consider only the increased durability of steel. A less striking, but perhaps equally important advantage, is that it has double the strength, and more than double the stiffness of iron. Some three years since, Mr. George Berkely made, in England, above 600 tests of the stiffness of steel and iron rails of equal section. The rails were supported on five feet bearings, and loaded with dead pressure at the middle. The first rails tried weighed 68 lbs. per yard, and loads respectively of 20 tons and 30 tons were applied. The average of 427 tests of the Ebbo Vale Co.'s and two other standard makers of iron rails, gave, with 20 tons, a deflection of $\frac{5}{8}$ in. and a permanent set of $\frac{1}{2}$ in. With 30 tons the deflection was $2\frac{1}{4}$ in., and the permanent set $2\frac{1}{16}$ in. With Brown's steel rails 45 tests gave an average deflection of but $\frac{5}{16}$th in. and a permanent set of $\frac{1}{8}$th in. With heavier rails and loads, the comparative stiffness of steel was more marked. The great and constant resistance to traction, and the wear and tear of track wheels and running gear, due to the deflection of rails between the sleepers and the perpetual series of resulting concussions, may be much reduced, or practically avoided, by the use of rails of twice the ordinary stiffness; in such a case, however, reasonably good ballast and sleepers would be essential. When a whole series of sleepers sink bodily into the mud, the consideration of deflection between the sleepers is a permanent requirement. If the weight of steel rails is decreased in proportion to their strength, these advantages of cheaper traction and maintenance will not, of course, be realized. The best practice here and abroad, is to use the same weight for steel as had been formerly employed for iron. Many attempts have been made in England, on the continent, and in this country, to produce a good steel-headed rail, and not without success. Puddled steel heads have all the structural defects of wrought-iron, as they are not formed from a cast, and hence homogeneous mass, but are made by the wrought-iron process, and are, in fact, a "high," steely wrought-iron. They are, however, a great improvement upon ordinary iron, although probably little cheaper than cast-steel heads. Rolling a plain cast-steel slab upon an iron pile has not proved successful. The weld cannot be perfected, on so large a scale, and the steel peels off under the action of car wheels. Forming the slab with grooves, into which the iron would dovetail when the pile was rolled into a rail, has been quite successful. The greater part of some 500 tons of such rails, made in this country, and put down where they would be severely tested, about four years ago, have outworn some three iron rails. Others failed in the iron stem, which was too light, after a shorter service. Rolling small bars of steel into an iron pile has been recently commenced at various mills in this country and in England. No conclusions are yet warranted by the short trial of these rails. There is a growing feeling among engineers and steel-makers that the compound rail, made wholly or partly of steel, will prove more safe and economical than any solid rail, and that the defects of the old compound iron rail, largely used in this State some years since, may be avoided since these defects were chiefly due to the nature of the material. The experiments in this direction will be watched with great interest by railway managers, for if the same durability can be obtained with a steel cap as with an all steel rail, the first cost will be greatly decreased. A rail made in two or three continuous parts, breaking joints, is also a practical insurance against disaster from broken rails.—*New York State Engineer's Report.*

ORDNANCE AND NAVAL NOTES.

Hydraulic Buffers.—Col. H. Clerk, R. A., F. R. S., recently read a paper before the British Association upon the effect of water used as a buffer to check the recoil of heavy guns, in which he describes an arrangement for the purpose, submitted by him to the Secretary of War. We find it given in the "Engineer" for October 15th: "It consists of a wrought iron cylinder closed at one end, the other end fitted with a cap and stuffing-box, through which a piston rod passes. The length of the cylinder and piston rod are regulated by the amount of recoil required. The piston fits well into the cylinder, and is perforated with four small holes. The ratio between the diameter of these holes and that of the cylinder is determined by the amount of work required to be performed on the water with which the cylinder is filled, enough air space being left to allow the displacement of water by the length of the piston rod due to the recoil. This air space also acts as an elastic buffer, and takes off the violence of the first impact of the piston on the water. The cylinder is firmly attached to the platform on which the carriage recoils, and the end of the piston rod to the carriage itself; so that on the discharge of the gun the carriage drives the piston through the water with an initial velocity V, whilst the water has to pass through the holes with an initial velocity R V, R being the ratio between the area of the cylinder and of the holes. This buffer has not only been used on shore with guns up to 25 tons weight, but also at sea, with light guns of only $1\frac{1}{2}$ cwt. and 8 cwt. in boats, and lately with 9.in. guns of 12 tons on board H. M. S. Prince Albert, in all cases with equal success.

"In place of water, it has been recommended to use oil, as there is less chance of corrosion taking place if the cylinder is kept full for any lengthened period, and no danger of the fluid freezing in ordinary frosts. The satisfactory manner in which this buffer has worked in checking the recoil of a gun of 25 tons weight leads me to anticipate that it could be usefully applied towards preventing, or diminishing, the destructive effects of a railway collision."

The "Devastation."—On Friday last the keel of the Devastation, a sister ship to the Thunderer, now building at Pembroke, was officially laid at Portsmouth. The Devastation belongs to the new class of iron-clads without masts or sails, dependent upon their steam power alone, and therefore suited especially for fighting, and not for cruising

ships. When completed, they will be unequalled for defensive powers, for heavy armament, and for the large capacity for carrying coals, which is, indeed, the vital element of their active existence. The London "Times" gives the following particulars of these vessels:

The Devastation and Thunderer are precisely alike in every respect, and when afloat will represent exactly the same amount of fighting powers and of speed. Their principal dimensions will be: Length, 285 ft; extreme breadth, 62½ ft; draught of water (mean), 26 ft; and burden in tons, 4,406. They will be clothed with 12 in. of rolled armor plating on a teak backing, built into a framing of immense strength, of 18 in. in thickness, and the whole backed up with an inner skin of iron plating 1½ in. thick.

In the Devastation the upper deck, when the ship is complete for sea, will be, as nearly as possible, 4 ft. 6 in. above the water, except at the bows, where a half sunk forecastle raises the height to a little over 9 ft. This height of the ship's bows will enable her to steam ahead to sea in rough weather, at the same time that it has been sufficiently kept down not to interfere with the fire of the guns of the forward turret over and round the bows of the ship. Although her free-board is as low as 56 in. above the water, her turret guns will be carried at a height of 13 ft., a height greater than that of any broadside armed iron-clad afloat.

There is no doubt that the Devastation will fight her guns at sea in such weather as would prevent the best of our broadside iron-clads opening their main deck ports, low as the former's upper deck is in the water. The explanation of this is, low as is the new ship's free-board by means of the armored breastwork which incloses the turrets and funnel, the virtual free-board for about one-half the length of the ship is raised fron 4½ ft. to 21 ft. At a considerable height above the breastwork deck there will be a hurricane or flying deck, from which the ship will be conned in heavy weather at sea, and to which access will be given by water-tight hatchways leading from openings in the breastwork deck. When the ship is in action all these openings will be closed by armor covers, and the ship will be worked from "conning hoods" formed of armor plates built up within the breastwork.

The turrets of the Devastation are mounted on Captain Cole's system, working on a series of rollers fixed at the circumference of the base of the turret, and centred on a central cylindrical spindle; but their base rests upon the upper deck within the breastwork, and does not pass through the upper deck, as is the case with the Royal Sovereign, Monarch, Captain, and other turret ships. On the turrets the armor plating will be 14 in. in thickness round the gun-ports, and 12 in. in all other parts, on an iron frame and teak backing of 15 in. and 17 in., with an inner skin iron plating of 1½ in. The diameter of the turrets will exceed 31 ft.

The offensive powers of the Devastation and her consort will consist of two 30-ton guns in each turret, and her capabilities as a ram. As regards the guns, they are intended to be of the pattern at present adopted in the navy—the Woolwich improved Armstrong—and will throw 600-pounder shot of the ogival-headed Palliser type. For her propelling power she depends solely on her engines, which will consist of a pair of the combined nominal power of 800 horse. The engines will drive a pair of twin screws, each working independently of the other. The estimated mean speed of the ship will be 12½ knots per hour under a full pressure of steam, and the stowage for coals reaches the exceptionally large amount of 1,600 tons. This latter, it is estimated, will enable the ship to proceed to the Mediterranean and return without calling between the times of her leaving Spithead and anchoring there again at the conclusion of her voyage; or, it would enable her to cross the Atlantic, fight an action, and afterwards return to a home port without having to renew her stock of fuel.

Each engine works independently of the other, and drives its own screw; so that under these conditions both engines must become disabled simultaneously to deprive the ship of her steam power. One engine, or one screw, may be rendered unserviceable for a time, but the other will remain available for the propulsion of the ship.

The complement of officers and men for the new ship will be 250 all told, a small number compared with the size of the ship, but quite sufficient for every purpose on board a ship where there is no work aloft. The comfort and health of all on board are well provided for.—*Engineering.*

BREECH-LOADERS.—The following list of the various breech-loading systems which have been adopted by the armies of the European States appears in the "Eastern Budget":—England—For the conversion of old rifles, the Snider; for new rifles, the Martini-Henry. France—For the conversion of some old percussion muskets, the Snider; for the new rifles, the Chassepot; a metal cartridge is now being made for the latter weapon, the old paper cartridge not being considered satisfactory. Russia—The Kruka for conversions, the 50,000 rifles already converted according to the Karte system having proved failures; Russia has also ordered 30,000 Berdan rifles from America, some of which have already arrived. Sweden and Denmark—The Remington, with Austrian barrels. Norway—Not settled. Italy—Pettiti; similar to the Chassepot (for conversions only). Switzerland—For conversions, the Millbank-Amsler; for new rifles, the Vetterli; Switzerland also possesses 10,000 Peabody rifles. Turkey—The Snider, for conversions. Belgium—The Albini. Spain—The Remington. North-German Bund—The needle gun. Bavaria—For conversions, the Lindner-Podelwils; for new rifles, the Werder. Holland—The Snider, for conversions. Montenegro has obtained 2,000 Kruka rifles from Russia. Austria—For conversions, the Wanzl; for new rifles the Wernal. Papal States—The Chassepot. Roumania—The Peabody.

ENGINEERING STRUCTURES.

ARCHED ROOFS.—We know not why, but the fact is not the less indisputable, that even to an uneducated eye the presence of a flat surface is abhorrent. Apart from any climatic influence, the exhilarating effect of a clear sky, exhibiting the entire grand dome of the Great Architect decorated with fleecy clouds, like the soaring monochromatic frescoes of a Sanzio or a Polydoro, is unconsciously responded to by all. On the other hand, when the vault is obscured by a thick flat curtain of lowering clouds, we share ourselves in

the depression of the heavens. It is as if one were transplanted from the centre of the stalls of a theatre to the back row of the pit, where the sagging floor of the balcony overhead debases the audience to the level of so many living Atlantes and Caryatides. From the operation of the same laws, we are quite confident that, sooner or later, the arch and the dome must have played an eminently important part in the science of decorative architecture; even in the absence of the wonderful mechanical properties of those structures by which a few cart-loads of worthless rubble are empowered to perform more useful work than the most colossal monolith ever quarried.

There is good reason to believe that arches existed in the pre-historic period. In its pointed form the arch was introduced in the pyramids of Gizeh and Meroe, and in the walls of ancient Etruria; to reappear, after the reign of the Roman semicircular arch, in the church of the Holy Sepulchre at Jerusalem, in the aqueducts of Constantinople. The analogous but more complicated structure—the dome—was almost coeval with the arch; brick vaults have been dug out in Nineveh; and the Church of St. Sophia, with its dome of earthenware and pumice stone 115 ft. in diameter, is a magnificent example of the powers of conception and the constructive abilities of the artificers of the sixth century. The brick Duomo of Florence and the shaped stone dome of St. Peter's, each about 140 ft. diameter, evidenced clearly that the architects of the fifteenth century were well up to their work, and that they considered a part of the latter to consist in the gratification of the natural instinct of the eye by the exhibition of arched and domed forms.

It is only now that engineers are beginning to recognize the immutability of the laws which render gracefully curved outlines so soothing to the eye. True, some of the noblest examples of arched viaducts are due to modern engineering; but we fear that we are indebted for these to the virtues of the arch as a carrying agent, rather than to any desire on the part of the engineer to gratify legitimately our organs of sensuous perception. We are borne out in this conclusion by the notorious fact, that when appearance is considered to be the first desideratum we have inflicted upon us straight soffitted, tinsel monstrosities, such as the Ludgate-hill Bridge of the London, Chatham, and Dover Railway, the contemplation of which is productive of a nausea which would be almost unendurable, were it not that an antidote is close at hand in the stately majesty of that giant in repose, London Bridge. If engineers had really reverenced the arch *per se*, apart from consideration of £ s. d., we should not so long have had little else than iron cobwebs for our station roofs, and it would not have been reserved to Mr. Fowler to illustrate the unchangeable nature of the laws of harmony, by the consistent adoption of gracefully outlined elliptical roofs for the covering of the Metropolitan Railway Stations. Such roofs differ as widely from the ordinary ridge and furrow type, as a Parisian umbrella differs from a flat-topped Chinese sunshade; the advance is simply from a state of barbarism to one of civilization.

On the Metropolitan Railway, with elliptical tunnels or bridges on either side of the stations, nothing less than elliptical roofs would completely satisfy the requirements of the eye. It would have been useless to attempt to effect a compromise with that organ by cambering the tie rods of the roofs or by any other similar makeshift. The same dodges have been tried over and over again in the Middle Ages; the tie beams were cambered, the hammer beams inclined towards each other, and in many instances, as at Outwell Church in Norfolk, curved braces were framed between those two members; in short, everything tending to assimilate the straight lined roof to the arch has been tried, and with a success proportioned to the degree of approximation to the perfect form.

The difficulties under which mediæval architects labored have no existence in this age of iron for engineers. If our forefathers wished to support their roof covering upon more durable roof ribs than the (four and a half centuries old) timber arches of Westminster Hall, or the still more ancient ones of Newstead Court, they could only resort to stone. To that material, consequently, they often did resort, and the stone principals, or gablets, 40 ft. span, still intact at the ruins of Mayford, and to engineers, by association, the still more interesting ones spanning the refectory at Conway Castle, afford pretty conclusive evidence that had these ancient masons been in a position to contract for the roofs of the Metropolitan Railway Stations, we should still have enjoyed our elliptical roof ribs, and their appearance would have been rather enhanced than detracted from by their execution in stone instead of in iron.

We fear, in this practical age, the delicate lines and curves of the Parthenon, or Temple of Theseus, designed to satisfy eyes that could not even endure a row of perfectly vertical columns—*fere nullam esse columnam quæ ad perpendiculum esse possit*—would not be appreciated; but we are at least justified in asserting that the most uneducated eye is qualified by nature to appreciate arched forms. We hope sincerely, therefore, that no more hideous square iron troughs, serving, but not expressing, the purpose of a bridge, and no more barn roofs done in iron, will be perpetrated in our metropolis, to serve as lasting memorials of the debased style of engineering architecture in this much vaunted Victorian age.—*Engineering.*

THE FOUNDATIONS OF LONDON BRIDGE.—In a recent report upon the communication between the north and south sides of the river Thames, Mr. Henry Carr furnishes the following interesting information upon the foundations of London Bridge, and their reliability: "The bridge is founded on piles driven 20 ft. into the clay, two tiers of sills at right angles to each other rest upon the piles, the sills are planked over, and upon the planking the masonry is placed. The space between the piles and sills underneath the planking is filled with brick-work and masonry. The weight of one of the middle piers and half of two arches, that is, the weight resting upon the foundation of one pier is 21,151 tons, which gives a load of 88 tons to be carried by each pile, and by the sills resting upon the pile heads. From experiments recently made at Mr. Kirkaldy's Testing Works, Southwark, it was found that a structure exactly similar to the timber foundations of the pier of London Bridge, so far from being able to carry 88 tons, yielded most seriously under 30 tons upon each pile.

"It is perfectly clear, therefore, that the pile and timber foundation is not equal to the work put upon it, and the sills are no doubt either crushed, or the piles are driven down; the weight of the bridge must therefore rest upon the ground of the

intermediate spaces between the piles, and the structure may be considered as resting on the clay, but with the bed disturbed and broken up; in fact, damaged by the pile driving. The weight per superficial foot, supposing the total equally distributed over the whole area, would be 6 tons and a trifle over.

"This is not more than is placed on some of the railway bridge piers (or rather columns doing the work of piers) across the Thames, but these railway columns have certainly as much to do as can safely be put upon them.

"From this examination it is evident that, although London Bridge stands well at present, it would not be desirable to put on additional weight, even if the additional weight were so small as probably to produce no appreciable effect; nevertheless, should additional weight be put on, and any settlement take place at any future time, the Committee might regret having increased the load upon a foundation which certainly has no strength to spare.

"There is one singular circumstance connected with London Bridge which probably may never have been brought under the notice of the Committee. The courses of the piers at low water incline towards the east. The eastern cutwater being in two cases as much as 10 in. below the western, this drop eastward is corrected to some extent in the superstructure, it being about 7 in. in the parapets. There are various reports as to the cause of this drop east; the letter from Mr. Morris, which is appended to the memorandum, gives an explanation which the Committee may perhaps think worth putting on record. The letter was written in reply to an inquiry as to whether the drop in the courses arose from a settlement of the foundations, or from what other cause.

"*Letter from Mr. Morris to Mr. Carr.*

"'Denmark-hill, *April* 15, 1869.

"'My dear Sir,—I am very pleased in being able to give you the information you require.

"'There never was any settlement of the piers of London Bridge. I made the drawings of that bridge for Sir John Rennie. Messrs. Jolliffe and Banks were the contractors; their principal master of the works was Mr. Henfrey, who was a very competent person, He had a young man with him, Mr. Hollingsworth, a relative. The foundations were constructed in cofferdams, and the pumps fixed at the down stream end, the piles driven, and the platforms were laid with an inclination towards the pumps. The stone was dressed in courses at the Isle of Dogs, brought up and laid with that inclination, Mr. Henfrey intending to change the incline courses into horizontal long before they approached low-water mark; but he died, and young Hollingsworth took the initiative, and did not discover the error before it reached the springing. He, no doubt, gained what he could afterwards.

"'I am, my dear Sir,

"'Yours very faithfully,

"'E. W. Morris.'"

—*Engineering.*

Making Foundations in Marshes.—A new process of making foundations for bridges in marshy soils has been recently used on a branch line of the Charentes Railway Company, in France. This line crosses a peat valley to the junction of two small rivers; the thickness of peat was so great that any attempt to reach the solid ground would have been very expensive. In order to obtain cheaply a good support for the bridge, two large masses of ballast, accurately rammed, were made on each bank of the river, and a third one on the peninsular between the two. The slopes of these heaps were pitched with dry stones, for preventing the sand from being washed away by the rain or by the floods in the river. Over the ballast a timber platform is laid; this platform carries the girders of the bridge, which has two spans of about 60 ft. each. When some sinking down takes place, the girders are easily kept to the proper level by packing the ballast under the timber platform; this packing is made by the plate-layers with their ordinary tools. This simple and cheap process has succeeded quite well. The same difficulty was overcome by a different plan on an ordinary road near Algiers. This road crosses a peaty plain, nearly one mile broad; the floods and elasticity of the ground prevented the formation of an embankment. The road was to be carried over a viaduct across the valley, but the foundations of this viaduct presented serious difficulties, the thickness of peat or of compressible ground being nearly 80 ft. It was quite possible to reach the solid ground with cast-iron tubes sunk with compressed air, or with any other system; but neither the implements nor the suitable workmen were available in the colony, and it was a great expense to bring them, and especially the workmen, from France. The use of timber piling was, of course, out of the question, as timber is very expensive in Algiers, and quickly becomes rotten; but there was a set of boring implements which the men used to work it. The engineers began boring holes 10 in. diameter down to the solid ground. These holes, lined with thin plate-iron pipes, were afterwards filled with concrete up to the level of the ground. Each of these concrete columns bears a cast-iron column; these columns are properly braced together and support the girders of the viaduct, which is divided into spans of about 20 ft., and is 20 ft. high over the ground. This system has succeeded very well, and is to be extended to another large valley.—*Mechanics' Magazine.*

The Oudh Canal.—The Government of India has just issued orders approving the designs of Captain J. G. Forbes, R. E., for a canal project in Oudh and the adjoining districts, much larger than that of the Ganges canal. The river Sardah flows from Nepaul into Oudh through the malarious jungle caused by the drainage of the Himalayas. From that river, water is to be taken off sufficient to irrigate 19,000 sq. miles between the Sardah and the Gogra on one side and the Deoha and Ganges on the other. Colonel Anderson, the Inspector-General of Irrigation, states that the cutting of the first 12 miles will cost half a million sterling and will be of greater magnitude than any yet carried out in India. The "Times" gives the following particulars of this undertaking: "The dam is to be made at Bumbassa, the canal head at Nuglah, 8 miles lower. A supply of 13,000 cubic ft. a second is required, and if the Sardah cannot give this at Bumbassa and Maggaen, lower down, the Korreallie river will help. The main canal will run through Oudh for 80 miles, and then bifurcate into the Benares canal, 280 miles long, and the Jounpore canal, 235 miles. But the project embraces the western districts also. The whole is estimated to cost close on five millions sterling,

and a return of 11 per cent. is estimated, after paying 4 per cent. charges. This is to be got, however, only by enforcing the severe provisions of Colonel Strachey's Bill, or charging the proprietors of irrigable but not actually irrigated lands 5½d. per acre. As so much of the canal will pass through Oudh, which has an abundant water supply from wells and marshes, Colonel Anderson takes a much less sanguine view of its prospects, nor does he expect the Oudh Talookdars or their tenants to take the water unless exceptionally low rates are imposed. The surveys for the proposed canal from Ragmahal to Calcutta are going on, and that land is being taken up for the canal from the Damooda at Raneegunge to Serampore or Howrah, on the south side of the Ganges and Hooghly. The line of canal in Sirhind, too, running chiefly through the Native States of Putiala and Nabha, is being surveyed. The cutting down of the expenditure on ordinary public works by so much as 1¼ million sterling a year will set engineers free for State railways and canals."—*Mechanics' Magazine.*

M. Boutet's plans for the construction of a bridge across the Channel are just now attracting great attention in France, and he is now engaged on a working model a hundred metres long, which will serve at once as a model of the bridge to be thrown across the Rance, at St. Malo, and of a part of the projected bridge across the Channel. By the direction of the Emperor, the model is to be erected on the Champs de Mars or in the Bois de Boulogne, and engineers from all coutries will be invited to inspect it. The same inventor is constructing a portable foot bridge of one span of a hundred metres, divided into 10 sections, which can be put together and thrown across a river in less than 5 minutes. This is intended for the use of the army, and is destined to supersede the present pontoon system. If the large working model we mention stands the trials it will be subjected to, an entire revolution in the construction of iron bridges and viaducts will be the result. M. Boutet's system, it should be said, involves the use of $\frac{1}{10}$ of the iron employed in bridges constructed on the usual plan.—*Railway News.*

Wrought-Iron Chimneys.—A new wrought-iron chimney has been recently erected at the Creusot Works. It is 197 ft. high, and 6 ft. 7 in. in diameter. At the bottom the diameter is increased to 10 ft. by a curved base, which is fastened by vertical bolts to masonry work. The thickness of the sheet-iron is $\frac{3}{16}$ in. at the top, and $\frac{7}{16}$ in. at the bottom. There is an inside iron ladder. The weight of this chimney is 40 tons; it has been riveted horizontally, and lifted afterwards with a crane. Another one, 275 ft. high, will soon be erected, but by a different system; it will be riveted vertically, with an inside scaffolding. These chimneys are built for an extension of the Creusot Works, especially intended for steel making. There will be eight Bessemer converters, where the cast-iron will be run direct from the blast-furnace; there will be also many Martin's furnaces, and an extensive workshop for melting steel in crucibles, where it will be possible to melt together 50 tons of steel.—*Engineering.*

A New Breakwater.—Mr. W. Jackson, of Windsor street, Brighton, has invented an original arrangement in the construction of breakwaters. This consists of a sort of honeycomb formed by fastening together in parallel lines a large number of cast-iron tubes; the structure is so placed that the waves flow through the pipes, that is to say, the axes of the pipes are parallel to the direction of the most dangerous winds or currents. Mr. Jackson has recently submitted to the War Office a scheme for the erection of a small breakwater according to his system, in Seaford Bay. He is not the first inventor of metallic breakwaters; Capt. Vetch, R. N., invented, some years ago, a system of iron caissons, which he proposed for the Plymouth Breakwater; and in 1857 Lieut. Manico, R. N., patented an apparatus which he called also a caisson, though it would be more accurately defined as a crate, which he proposed to fill with stones, so as to form submarine blocks. Mr. Jackson's breakwater is widely different, however, from Capt. Vetch's and Lieut. Manico's inventions. The latter are proposed to be used in the body of a pier or sea defence; the former, according to the inventor's ideas, should be placed at some distance outside. We have had no opportunity of seeing the tubular breakwater tested, though the inventor says he has erected one at Odessa, and that it has answered very well.—*The Engineer.*

NEW BOOKS.

A Treatise on the Richards Steam-Engine Indicator, with directions for its use. By Charles T. Porter. Revised, with notes and large additions, as developed by American practice. With an Appendix containing useful formulas and rules for Engineers. By F. W. Bacon, M. E., Member of the American Society of Civil Engineers. New York, D. Van Nostrand, 1869.

We welcome this book from the hands of practical men. It supplies a want that has long been felt by working engineers. No one can claim to be an accomplished engineer, without a knowledge of the Indicator and its uses.

Now that we have an improved instrument that can be applied to any steam-engine, from the slow-moving marine to the swift locomotive, the Indicator is becoming an indispensable appliance, and is coming rapidly into use.

The original work, by Mr. Porter, published by Elliott Brothers, London, is a valuable work; but the American engineer requires examples from motors with whose working he is more familiar.

The American editor has retained the general description of the instrument, the sample diagrams, and the analysis of the original work. To this he has added diagrams from the most approved American marine, stationary, and locomotive engines, prepared from the originals, taken by himself.

It is believed that the locomotive diagrams are the only ones ever obtained in this country from an express engine while making a regular trip. The American engineer will feel gratified when he compares these "cards" with English diagrams, taken in a similar manner.

Mr. Bacon has added an appendix, containing useful tables and formulas.

The rules for proportioning belts to any required transmission of power, are exceedingly valuable.

The reputation of the American editor, among practical engineers, will insure an extensive demand for this little book.

A PRACTICAL TREATISE ON CONCRETE AND HOW TO MAKE IT. By HENRY REID, C. E. London: E. and F. W. Spon.

Less than a year has elapsed since we had occasion to copy from the New York "Tribune" a notice of a work by the same writer, entitled "A Practical Treatise on the Manufacture of Portland Cement." In that notice special attention was called to the fact that a large portion of the work was nothing more nor less than a wholesale plagiarism from General Gillmore's standard American "Treatise on Limes, Hydraulic Cements and Mortars," for which no credit or acknowledgment whatever, nor the slightest reference to the source from which it was drawn, was made by the writer. Entire pages and subjects were appropriated bodily without alteration, not as extracts or quotations, but as new matter, and were given to the public as such.

In the present treatise on "Concrete," this literary theft and professional discourtesy is continued in the same wanton spirit which characterized its predecessor. The book contains five plates of drawings, one of which represents a well-known device for testing the strength of mortars. The other four are exact copies of plates in General Gillmore's work, taken by Mr. Reid for his own use and benefit, without any recognition of the ordinary and usual amenities of trade or professional intercourse. The readers of the Magazine will therefore readily infer that at least a portion of Mr. Reid's book possesses merit, and that he is, to some extent, a judicious and skilful gleaner in fields over which others have thoroughly worked before him.

This English publication is a mere compilation from well-known sources, and contains nothing that is new to the profession, while the bulk of it is of no practical use or application in this country.

THE HISTORY AND PROGRESS OF THE ELECTRIC TELEGRAPH, with descriptions of some of the apparatus. By ROBERT SABINE, C. E. Second Edition, with additions. New York, D. Van Nostrand, 1869.

This neat little book gives a detailed description of the various telegraphic systems at present employed, with many that have been superseded by recent improvements.

The numerous diagrams aid the reader to comprehend the more complicated systems.

Among the topics treated are Early Observations of Electrical Phenomena; Telegraphing by Frictional Electricity; Telegraphing by Voltaic Electricity; Telegraphing by Electro-Magnetism and Magneto Electricity; Telegraphs now in Use, including: The Needle; Morse Dial; Type Printing; Electro-Chemical and Copying Telegraphs; Overhead Lines; Submarine Lines; Underground Telegraphs, etc., etc.

COUNTERPOISE GUN CARRIAGES AND PLATFORMS. Published by direction of Brevet Major-General A. A. HUMPHREYS, Brig. Gen. and Chief of Engineers, U. S. A. For the use of officers of the Corps of Engineers. By Capt. W. R. KING, U. S. Corps of Engineers, Brevet Major, U. S. A. Washington, Government Printing Office.

Capt. King's report is published in a quarto volume of sixty pages of text and seventeen folding plates.

The author thus defines his subject: "The object of this class of inventions is to secure additional cover for barbette guns when "out of battery," and this is generally sought by allowing the gun to descend, either during or immediately after the recoil, to a lower position than that occupied when "in battery."

In order to prevent the too rapid descent, and to facilitate the raising of the gun after loading to its proper position for firing, a counterpoise of some kind is generally employed, and this latter, though not always used, may easily be shown to be essential to the proper working of the carriage, especially for the heavier calibre of guns. We may, therefore, in the absence of a better name, call them "*counterpoise gun carriages.*"

The report is confined to a classification and detailed description of the various methods comprehended in the above general definition. This work is exceedingly well done. For sale by Van Nostrand.

THE METALS USED IN CONSTRUCTION — IRON, STEEL, BESSEMER METAL, etc., etc. By FRANCIS HERBERT JOYNSON. Edinburgh, William P. Nimmo, 1868. For sale by Van Nostrand.

The chemical and physical properties of the various "irons" now in use are clearly set forth in this little work of Mr. Joynson's.

The smelting processes are briefly treated. The subsequent operations of puddling, toughening, converting cast into malleable iron, and steel making, make up the bulk of the book.

One chapter is devoted to annealing, case hardening, and tempering iron and steel.

The book presents a concise statement of the methods employed in producing the most useful of the metals, and is designed rather for the general reader than the scientific student.

HOW TO BECOME A SUCCESSFUL ENGINEER, being Hints to Youths intending to adopt the profession. By BERNARD STUART, Engineer. Fourth Edition. Edinburgh, Wm. P. Nimmo. For sale by D. Van Nostrand.

In the absence of systematic technical education for engineers, such hints as this author affords are well timed.

The kind of study, and the proper routine of experiment, is clearly set forth for the especial benefit of those who are seeking both instruction and advice.

The student of engineering finds it extremely difficult to reconcile the advice he gets from professional instructors, with that which is given him by practical and successful men.

Our author endeavors to indicate what knowledge is of most worth to him who would become a successful engineer. It is already meeting with a large sale in this country.

THE MECHANIC'S AND STUDENT'S GUIDE in the designing and construction of General Machine Gearing, Eccentrics, Screws, Toothed Wheels, and the drawing of rectilineal and curved surfaces, with practical rules and details. By FRANCIS HERBERT JOYNSON. Edinburgh, Wm. P. Nimmo.

This work is designed especially for draughtsmen.

The text affords a course of instruction in progressive exercises of the eighteen folded plates, which form a part of the volume.

The typography and engravings are exceedingly well done.

RECORDS OF STEAM-BOILER EXPLOSIONS. By EDWARD BRINDON MARDON, Chief Engineer to the Midland Steam Boiler Inspection and Assurance Co. E. & F. H. Spon, London.

This book of about one hundred and fifty pages, is in four parts; the first being a paper on steam-boiler explosions, read before the meeting of the Institution of Mechanical Engineers, at Manchester, England. The remaining parts are respectively very brief records of explosions in 1866, 1867, and 1868.

The author concludes that "boiler explosions do not arise from mysterious causes, but generally from some defect which would have been remedied if it had been known to exist." The illustrations, 166 in number, are poorly executed, but are of great practical value from their undoubted correctness. For sale by Van Nostrand.

GUIDE PRATIQUE DE L'OUVRIER MÉCANICIEN. Par M. A. ORTOLAN. For sale by D. Van Nostrand.

An excellent work for the purposes indicated in the title. The book begins with short treatises on Arithmetic, Algebra, Practical Geometry, and Trigonometry. These, of course, are mere outlines, but contain whatever is necessary for the understanding of the body of the work, which deals with Practical Mechanics. The chapters on Transmissions des Mouvements and Machines Motrices Hydrauliques are especially good. A fine descriptive atlas accompanies the text.

COURS DE MÉCANIQUE THEORIQUE ET APPLIQUÉE. Par MM. FUSTUGUERAS ET HERGOT. For sale by D. Van Nostrand.

This little work is one of a series intended for the use of practical men. Its treatment of subjects is very clear and complete, making but little use of mathematics. The illustrative engravings are very fine.

The subjects, in their order of treatment are: Moteurs en General; Moteurs Animés; Du Vent Comme Moteur; Mouvement des Fluides; Recepteurs Hydrauliques; Recepteurs à Axe Horizontal; Turbines; Travail dans Machines à Vapeur; Divers Organes des Machines à Vapeur; Systèmes des Machines à Vapeur; Machines à Air Chaud; Machines à Gaz.

THE EARTH'S CRUST: a Handy Outline of Geology. By DAVID PAGE, F. R. S. E. Fourth Edition. Edinburgh, Wm. P. Nimmo, 1868. For sale by Van Nostrand.

The title of this book explains its scope. The author is well known, and is one of the most successful among scientific writers, in popularizing technical science for general readers.

The book before us presents an outline of geology, such as any well-informed mind would like to possess, and is designed to stimulate the reader to the study of works of a fuller and more systematic character.

MODERN WORKSHOP PRACTICE, as applied to Marine and Locomotive Engines, Floating Docks, Dredging Machines, Bridges, Ship Building, Cranes, etc. By JOHN G. WINTON. Strahan & Co., London.

This is designed to form one of the famous Weale series. It is thoroughly practical, and will prove valuable not only to mechanical engineers, but to inventors who desire to attain a better familiarity with the technical terms and empirical formulas of the shop, than is afforded generally by the rudimentary works. For sale by Van Nostrand.

FREE-HAND DRAWING: A Guide to Ornamental, Figure, and Landscape Drawing. By AN ART STUDENT. Profusely Illustrated. Edinburgh, Wm. P. Nimmo. For sale by Van Nostrand.

The several chapters of this treatise give instruction in Relation of Materials; Free Hand Drawing of Lines; Shading; Application of the Principles to Elementary Subjects, and Sketching from Nature.

It is one of the Handy-Book series of the well-known Edinburgh publisher.

AN ESSAY ON A NEW SYSTEM OF FORTIFICATION. By GEORGE E. HEAD, A. M., Captain Twenty-ninth Infantry, and Brevet Major, U. S. Army. With Illustrations. New York, D. Van Nostrand, 1869.

This is a pamphlet in quarto form, containing twenty-four pages of well-printed matter, interspersed with a sufficient number of diagrams to explain thoroughly the author's system.

The invention involves the use of heavy guns, mounted in turrets; the latter to be capable of being worked vertically in excavations.

THE ELEMENTS OF BUILDING, CONSTRUCTION, AND ARCHITECTURAL DRAWING.—With one hundred and thirty-three illustrations, drawn on wood, by the author. By ELLIS A. DAVIDSON. Cassell, Peter, and Galpin, London and New York.

The object of the author of this book is to give a general knowledge of the principles of building construction, and at the same time to afford practice in architectural drawing. The book will be of service to students of practical science, who desire an easy introduction to the technicalities of building.

A PRACTICAL TREATISE ON MILL GEARING, WHEELS, SHAFTS, RIGGERS, etc., for the use of Engineers. By THOMAS BOX. London, E. & F. N. Spon. For sale by Van Nostrand.

Of several excellent works on this subject, this is the most compact, and it seems to us the most serviceable.

The author is favorably known among engineers, through his former works upon Hydraulics and Heat.

LONG AND SHORT SPAN RAILWAY BRIDGES. By JOHN A. ROEBLING. Published by D. Van Nostrand.

We call attention to the article on p. 78 of this number with reference to this book.

MISCELLANEOUS.

OPTICAL CORRECTION IN DESIGN.—Optics, or that branch of it which more particularly relates to the phenomena of unassisted vision, is a study architects and those interested in design generally would do well to investigate. Every architect at least knows that his elevations, sections, and other geometrical drawings do not correctly represent the actual structure as regards projection or proportion of parts, and that he has frequently recourse to perspective to aid him in arriving at

that due modification and effect of masses and grouping which distance, position, and other considerations would give to his design. Many, it is true, sadly overlook these considerations, especially the effect of distance and angle under which the actual building will most generally be viewed. How frequently, for example, do we find cornices cutting off from sight the parapets of buildings; chimney stacks placed so as to interfere with general outline, and ornamental and other accessories so located as to be lost altogether from view. Countless buildings and features of them have been marred, obstructed, or miserably mangled by disregard or ignorance of the principles of optical projection. It may be said a building cannot possibly be viewed from the same point at all times and under all circumstances. This is true; but there is generally some point or points of a structure more accessible than others to spectators or those located within its walls, and it is from these points of sight that I conceive a proposed building should be considered; its masses, grouping, and features studied on paper after the demands of arrangement and construction have been fulfilled.

Perspective itself is a practical application of the theory of optics, and a branch of art more neglected than it should be by architects, who often deem it a subsidiary method of representation, or who either wilfully or ignorantly misrepresent its principles; and this is the more inexcusable as it then becomes an art of falsifying, instead of truthfully rendering on paper, the design of the architect. It is a branch of study, indeed, whose thorough acquaintance an architect should pride himself in possessing, in addition to the other means of geometrical representation which every builder or mechanical workman can possess. I shall not here consider the principles of an art on which many treatises obtainable by all have been written; simply observing that its essence lies in its accuracy. Moreover, the position of the "horizontal line" or "point of sight" should never assume fictitious altitudes or positions, nor the "points of distance" be exaggeratedly extended or improperly limited, as is often done in competition drawings. The "picture plane" is also frequently assumed to be in false and impossible positions.

I shall here confine my readers' attention to some of the more important instances of the value of optical correction, or, more properly, that *compensation*, in design itself which perspective does not consider, but which critical experience has forced upon the attention. One of the most remarkable of the illusions of which a correct eye becomes cognizant is the *apparent* concavity or depression which perfectly straight lines or boundaries possess. The theory of this peculiar property seems, I think, to be that retention by the retina of the eye of those visual rays which proceed from definite points or limits of an object. The more striking points of the object by a "persistence or impression" are retained, the intermediate rays of pencils being comparatively lost to the sight. Thus, in limited or terminable straight lines, as a straight lintel, beam, or architrave, the extremities are immediately caught, and the persistence of impression of those points gives them a prominence upon the retina disproportionate to the other intermediate rays from the object. Irradiation is a phenomenon of optics very akin to this property, by which the impression made upon the retina extends beyond the size of the real image. The theory of binocular vision may be said partly to explain the above phenomenon; but I do not think, from experimental knowledge, that it can satisfactorily do so.

Vitruvius alludes to this peculiar defect of vision in his "Treatise on Architecture," which shows that this property was not unnoticed in the age of Augustus. He says: "If we do not endeavor to gratify the eye in its sense of beauty by proper proportions and *increase of size* when necessary, and thus remedy the defect of vision, a work will look clumsy and disagreeable." It is not only of the entasis or swelling of columns that Vitruvius speaks, but also of horizontal lines of buildings, as the line of the "stylobata" or upper step of the Greek temples. This, he says, should not be a straight line, but should be "very gently arched—highest in the centre, for if it be set out level, it will have the appearance of being sunk in the centre." The line of capitals, he further remarks, is to follow the inclination of the stylobata. The researches of the late Professor Cockerell, Mr. Penrose, Mr. Donaldson, Mr. Pennethorne, Jopling, Bell, and other mathematical critics, have gone to corroborate the passage of Vitruvius, and to prove beyond doubt that the parabolic, catenarian, or other curves, were employed by the ancient Greeks to compensate for the apparent deflection in the straight lines and surfaces of their structures. As we have noticed, this compensatory swelling or "entasis" is as much needed in horizontal members as cornices, beams, girders, and every feature which is "straight" or level, as it is necessary in the contour of our columns, shafts, and spires, though, as we shall see by and by, it is seldom applied to the latter purpose. Flat surfaces, also, as walls, are visibly subject to the same peculiar concavity as perfectly straight lines or boundaries. I will endeavor to show in the next and concluding paper, the application of the above compensation for this ocular deficiency.

Other delusive effects, explained on optical principles, such as the opposition of contrasting lines; the junction of curvilinear with straight; the relative proportioning of parts and features, demand attention in design. Æsthetically speaking, and every artist knows it, there is a good deal in easing abrupt junctions and harshnesses; in giving a slight convexity here and a gentle curve there; in harmonizing proportions and parts, before architectural designs can bear that stamp of æsthetic excellence and ideal refinement which should be the great aim of every educated architect.—*The Building News.*

British Light-houses.—We republish, from the "Pall Mall Gazette," the following particulars relating to the condition of the light-houses and floating beacons which protect the shores of the United Kingdom, and which were obtained from the last published parliamentary reports, and which point out the numerous glaring deficiencies in the existing system.

There were, in 1861, 212 lights on the English coast, of which 82 were shore lights under the Trinity House, 89 under local authorities, and 41 floating lights, of which 37 were managed by the Trinity House. In Scotland there were 46 light-houses under the Commissioners of Northern Lights, besides 67 fixed, and one floating light under local authorities, making a total of 114. The Ballast Board of Dublin managed 69 light-

houses and 4 floating lights, while only 4 fixed and 1 floating light were under local authority. A curious table is published comparing the number of British and French lights in proportion to the length of coast line. England has a light for every 14 miles of coast, Scotland one for every 39½ miles, Ireland one for every 34½ miles, while France exhibits one for every 12.3 miles. The light-houses in France are thus shown to be more than three times as numerous as in Scotland, compared with the amount of coast, and nearly three times as numerous as in Ireland. It ought, however, to be observed that the floating lights are not taken into account in this table. The lights of this description on the English coast, the value of which every mariner is ready to acknowledge, bring the English average up to 1 light for every 11.37 miles of coast, as compared with the French 12.3. The English lights have been steadily and gradually increasing in number, according to the advancing requirements of trade, during the last 150 years, while the French, which were very few until 1825, were, soon after that date, largely augmented by the erection of additional lights in the best positions, and in accordance with a well-considered and comprehensive plan. No other country of Europe, except France, is so well guarded as the United Kingdom.

The first-class lights, under the control of the Trinity House, are unsurpassed in brilliancy by any exhibited on foreign coasts. There are two principal means by which the stream of light from the lantern of a light-house is thrown in the required direction; one is by silvered parabolic reflectors, and is called the catoptric system; the other is by a series of concentric refracting lenses, which is known as the dioptric system. There are also, in some light-houses, combinations of the two systems, such, for instance, as those distinguished by the names of catadioptric and holophotal. The principle of refraction is generally adopted in Scotland, while reflectors have still a numerical preponderance in England and Ireland. This may, perhaps, be accounted for in some degree by the modern date of most Scotch light-houses as compared with those of the sister kingdom. While praise may generally be given to the mode in which the lights are maintained by the great corporations, the lights of the smaller local authorities are not so deserving of commendation — smoky lamps, candles, and tin reflectors, some of them even painted in front, may be found. The Royal Commissioners reported of Dover light that "the reflectors were incrusted with dirt, the glass of the lantern was covered with soot, which adhered to the fingers when the glass was touched on the inside. . . . It was evident that the lantern and reflector had not been cleaned for some time. . . The place where the lanterns are lowered during the day was locked, the key lost, and it was necessary to break into it with a hammer. If the lamps which light the important port of Dover are inefficient, what is likely to be the case of 170 local authorities at small and unimportant harbors? At Aberystwith, on the 25th of October, 1859, the harbor-master went to bed without seeing that the pier and guide lights were put up. Before morning several wrecks had occurred, and many lives were lost.

In France the whole system is symmetrical. Lights are placed on a system—that their lights should cross. They are inspected on a system. The size of the flame, the quantity of oil to be consumed in an hour to produce a good light, and every minutest detail is calculated to a nicety. But no such supervision is now possible in the British Islands. If there were one central light-house board for the whole kingdom, with resident representatives for Scotland and Ireland, it would naturally be its business to carry out in minute details those plans which had proved most efficient.

In all foreign countries it seems to be assumed that light-house illuminations should be intrusted to persons selected for their fitness in these respects. Engineers, hydrographers, and professionally scientific men are always included in their board of administration. But in England no scientific element exists at all.

SURVEYING AND LEVELLING IN CHINA.—A small volume of "Lectures upon Chinese Rural Economy," which appeared not long since in St. Petersburg, from the pen of a well-known Russian writer, long a resident in China, M. Skatchkoff, affords some curious particulars respecting the practice of surveying and levelling amongst the Celestials.

The unit of land measure in China, M. Skatchkoff tells us, is the *bû*, or fathom, which contains 5 Chinese ft. or *tse*. The Chinese foot, like the English, is supposed to have had its origin in the average length of that portion of the human frame whence it derives its name. Its value is about $1\frac{1}{24}$ English ft. The *bû*, or fathom, is consequently equal to $5\frac{5}{24}$ English ft. 240 sq. *bû* make a Chinese acre, or *mû*, which is equivalent to .16 of an English acre. This is the measure recognized in the assessment of the land-tax. It is distinguished, accordingly, as the "Government" or "Treasury" *mû*. There are two other varieties of acre occasionally employed—the "agricultural" containing 360 sq. *bû*, and the "great" *mû*, which is equal to 720 sq. *bû*. All these varieties have been in use from a very remote period. There is, however, reason to believe that, in ancient times, the "great" *mû* was most frequently employed—a fact which should be borne in mind in any investigation of the agricultural statistics given by early Chinese writers.

There is still another description of land measure—the *tsaen*—which includes a "treasury," an "agricultural," and a "great" *tsaen*, the latter being equivalent to 5¾ English acres, nearly.

The measurement of land is performed on the principle of chain-surveying. The chain is replaced by a line divided into fathoms and fifths (ft.), which is wound upon a reel fitted into an oblong wooden box. The latter contains, in addition, a supply of black paint for writing, and the small camel's-hair pencils or "stumps" which take the place of pens with Chinese scribes. 10 iron pins are used with the line, as by English surveyors.

As early as the fifth century of our era, it appears to have been customary for the governors of Chinese provinces to notice in their annual financial reports the changes in extent and assessable value of the cultivated lands within their jurisdiction. About the year 1000 A. D., however, a general survey was made of all the occupied lands in the empire, and a species of Doomsday-book was compiled for each province. This system has remained in force ever since. At the outset all the occupied lands were classed under one of the 5 following heads, viz., rocky or woody, hilly, champaign,

marsh, littoral. Three qualities of soil were recognized under each head—good, medium, and poor; and three descriptions of culture—good, middling, and indifferent. Subsequently, with a view to obviate the difficulties arising from the occurrence of several varieties of land within the same enclosure, it became customary to regard every separate plot of ground as divided into a number of equal parts, varying from 10 to 40 according to the character and value of the property, the quality and assessable worth of each sub-lot being registered separately if necessary.

M. Skatchkoff relates that during his sojourn in Djoungaria (Chinese Tartary), he was an eye witness of the labors of a survey commission, employed under the orders of the Pekin Government in setting-out certain new lands, distant about 30 versts from the town of Tchoutchoutchuk, in 250 *tsian* (six-penny) lots. The registration was performed by 2 Government clerks, under the superintendence of the commissioners. The field-work of the survey was executed in like manner, under the personal supervision of the commissioners, by 10 deputies chosen by lot from a list prepared beforehand of 350 applicants for the lands aforesaid. No outlay was incurred by the Government in these operations, as the expenses of the survey, which did not exceed 10 roubles, or 30 shillings in all, were charged prospectively against the future occupants of the allotments.

The canal system of the Chinese empire, and the universal application of irrigation, with its numerous ingenious adaptations, sufficiently testify to the practical skill of the inhabitants in hydraulic science. But the processes of levelling are conducted in a very primitive fashion.

The instrument employed is a modification of the water-level—an oblong trough of buckthorn or other similar wood, clamped with iron, and open at the ends. The interior surfaces of the sides are ruled horizontally with fine parallel lines in red or black paint, to serve as guide to the observer's eye. The trough is suspended by a single cord from a hook fastened beneath the apex of a wooden tripod stand. The usual height of the latter is 4½ ft. The instrument is adjusted by pouring water into the trough—which is deeper in the centre than at the extremities—and then shifting the suspending cord or the legs of the tripod until the surface of the water coincides with a pair of the horizontal lines. With this level and with the measuring-line and pins before described, all the requisite "field work" is readily and effectually, if not very expeditiously, performed.

All matters connected with the water-supply are intrusted to a guild with an unpronounceable name, the members of which receive special instruction in subjects appertaining to hydraulics.

M. Skatchkoff adds that geographical manuals exist of each district, which, besides a great variety of statistical information, contain the most minute details of its topographical, and especially of its hydrographical features. Many of these works are issued by the Government at very low prices, and revised editions appear from time to time.—*Engineer.*

The Hydrostatic Test.—The application of hydrostatic pressure to steam boilers, with a view to determining their fitness for use under steam, is so universal a practice with builders and inspectors, that to question its utility and propriety, is to inspire doubts as to the thoroughness of one's engineering education, and invoke severe criticism; and yet, it cannot be denied that much damage results from the system as practised. It is usual to delegate the duty of "testing," to persons totally unacquainted with the strength of iron or the damaging effect of sudden increments of pressure upon sheets already heavily strained; or, at least, they are not selected because of any particular fitness; and, in consequence, injudicious strains are placed on boilers, and the tensile strength of the iron seriously impaired thereby. We have frequently been told by steam users when discussing the relative merits of various systems of inspection, that they feel perfectly secure, because their boilers were built under special contract, and were subjected by the maker to 200 lbs. cold pressure, meaning to have us infer, that after such usage, they must surely not fail under 100 lbs. of steam; but we have made it our business to probe these parties further, and discover that seams were strained, braces broken, bolts sheared off, or insufficiently stayed surfaces distorted. These are the apparent results,—that which they don't see is the most injurious, and cannot be remedied as are the others.

They remind us, too, that the ultimate tensile strength of good iron is 50,000 to 60,000 lbs., forgetting that all the material used in construction, —indeed most of it will not bear more than half that amount, and further, that experience demonstrates the necessity of recognizing but about one-sixth of this figure available in constant use.

Let these persons, so confident of the ability of their boilers to withstand such severe and frequent tests, estimate the accumulated pressure of 100 lbs. per sq. in., or, a single inch of the boiler's length, measured, we mean, in the direction of its axis, and stand aghast at the tremendous force constantly struggling to free itself from its iron prison; or, will they prefer to listen to the result of an experiment, made during the past summer, at the Fort Pitt Iron Works, Pittsburg, Penn., with a cylindrical boiler, constructed of steel plates ¼ in. in thickness, by that establishment, for the Government, with a view to testing its adaptability to such use, relatively with iron. The trial was made in presence of the proprietors of the works, the Government engineer officer—under whose supervision it was built—the eminent constructing and mechanical engineer, Thatcher Perkins, and others. Measurement of the "girt" of the boiler was made—with a steel tape—before and during the process of pumping in cold water, and, when the pressure reached 780 lbs., a permanent enlargement of 3¾ in. was found to exist, in the direction of the circumference of the boiler, —*though no leaks were visible,*—and at 820 lbs., rupture occurred. It were well here, not to overlook the influence of the successive strokes of the pump, acting as a "water ram" on the pregnant boiler.

There is no doubt that boilers are very often severely and permanently injured, by the hydrostatic pressures to which they are subjected, in order to prove that they are strongly built. Each successive test weakens them, until they fail to respond to the requirement to longer bear the burden, and rupture, as did one recently at Mobile, while under the manipulation by this intelligent process of the United States Government *Inspector.*

But there is another feature. So popular has this method become, that implicit confidence is placed in it by many, who frankly deny that any

further test of a boiler's capacity for sustaining steam pressure is necessary. Not a month since we were informed by a deputy State Inspector—who, by the way, was an executive, and controlled subordinate deputies, that he *had* and could again *pass* boilers without having seen them. So expert had he become, that he cared simply to see the gauge (affixed to the pump in an adjoining apartment), and to note that it held the maximum pressure for 2 minutes. This was sufficient. What to him were blistered and burned plates, incrusted surfaces, corroded sheets, slack or broken braces, unskilful workmanship or faulty design? The iron had once more submitted to the demand of its annual inquisitor, regretting that he was not likely to be in charge when the exaustion oi its waning strength culminated in disaster.

We have recently been solicited to write on a boiler, whose fire sheet is so badly burned and blistered as to be positively dangerous; the firm is constantly changing engineers in their endeavor to get one who will stolidly risk his life and reputation, and the lives and property of others, without entering his protest; and upon what do the owners base their presumptuous, perhaps criminal conduct, in refusing to make needed repairs? Upon the certificate of the State Inspector that their "boiler has withstood a hydrostatic pressure of 135 lbs., and is safe to carry 90 lbs. of steam." For how long is this already dangerous condition to continue? For 12 months.—Ten yet to elapse! May we not reasonably look for some damage in this direction, ere long?—and when it does occur. at whose door shall the censure be laid? We shall pursue this subject further in our April number. —*The Locomotive.*

The Physical Commotions throughout the Globe.—These commotions still continue; but the crisis would appear to have passed, if the diminished force of the various manifestations is to be trusted. There have, however, been recent earthquakes in Germany, as well as in Italy and France, and in Russia and India,, as well as in Australia, and South and North America,—in short, over all the globe. Professor J. Phillips, of Oxford, in his recent book on Vesuvius, gives it as his opinion, which accords with our own previously expressed idea, that the earth is now passing through one of its periods of volcanic activity. How long that period may last, no one can say. Of late the theory has been advanced that earthquakes are caused by the influence of the sun and moon on the internal waves of the molten sphere. A Mr. Rudolf Falb has lately written in defence of this hypothesis. Our own, as our readers know, is that there is a continued pressure of rotation upon the crust, from the molten mass of the interior, which molten mass we still believe in, with many geologists, notwithstanding recent opinions to the contrary. This pressure from within has crises, during which its centrifugal tendency to expansion rends the crust, and so relieves itself, while the rents are healed, as it were, by intruding molten matter, which solidifies and re-cements the crust. The rendings are greatest in the more equatorial regions, and just because it is there that the centrifugal power of the rotation is greatest; but by reaction of the pressure, earthquakes and volcanic belchings from the interior occur even in such circumpolar regions as Iceland, and in intermediate districts such as Italy.

It was the opinion of Mr. Hopkins, of Cambridge, or rather his demonstrated conclusion fron elaborate geological and mathematical investigations, that the power which has produced all the great rendings of the earth's crust must have been a power operative upwards from within; and this conclusion supports our idea that they arise from the rotary pressure of the molten and more mobile interior upon the less mobile or less yielding crust of the sphere. If the power of the rotation tends to increase with the known diminution of the obliquity of the ecliptic, the circumference of the sphore must be expanding; or, in fact, the molten and incrusted sphere must be growing in dimensions; and how far this may go on, or what may be its limits in the course of ages, it may be hard to say. We have already spoken of the instructive light which the state of the other planets, as to coincident rapidity of rotation, size, and levity, sheds on this question.

The tidal wave predicted by Leut. Saxby, as a consequence of the co-ordinate position of both sun and moon, did not occur with us to the anticipated extent, at the time predicted; but there have been tides since 3 ft. higher than the dreaded one, and which have done much damage on the banks of the Thames from not being looked for. The Americans say that the tidal wave on their shores rolled in as high as 18 ft. at Newcastle, New Hampshire, where it ran 125 ft. beyond high-water mark; and elsewhere, as at the Bay of Fundy, there has been an enormous tide, with destructive floodings.

If the angle of the ecliptic was ever of *much* greater extent than it is, the most tremendous tidal waves of later ages must have been as nothing to what probably once occurred, when the world may have "stood out of the water and in the water, so that the world that then was, being overflowed with water, perished," as St. Peter so mysteriously tells us, in regard to the Scriptural deluge.—*The Builder.*

Preventing Boiler Incrustation.—Every steam user who has been troubled with scale in his boilers—and very few have not—has doubtless tried to effect its cure by means of one or other of the various boiler compositions before the public. Some may have succeeded; some, to our knowledge, certainly have not. This may have been owing to various circumstances; amongst others, that of using the proffered remedy without ascertaining its chemical fitness for the water in which it was to be used. It has been too much the custom to assume that a given boiler composition will prove perfectly effectual in every kind of water. This mistake has only been found out after fruitless efforts to remedy the evil, but which, by a discriminate selection, might have been cured. Steam users, however, who have hitherto been unsuccessful in preventing scale, will be glad to learn that a very perfect remedy is now being brought before the public by Mr. Smith, of 204 High Holborn, London. This preparation is a powder composed of several ingredients which are very certain in their action in preventing scale and perfectly harmless in their effect upon the metal plates. It is now more than a year since Mr. Smith first brought out this preparation. During that time it has been used by a number of firms whose testimony to its merits we have seen. We select, from a number of testimonials, two from parties whose names are well known to our readers. The first is from Messrs. Merryweather and

Sons, the steam fire engine manufacturers, who, under date of January 21, 1869, write: "We have used your boiler composition in our steam boilers, and find it to surpass, in our estimation, all others that have hitherto been used by us. We find that half the stated quantity is quite sufficient to keep our boilers free from deposit."

The second testimonial, which is dated March 16, 1869, is from Mr. Field, the inventor of the boiler bearing his name, and is as follows: "I am tired of trying various preparations supposed to prevent incrustation in steam boilers. As regards your own composition, I have as yet only given it a partial trial in the case of a large Cornish boiler, in which the incrustation was very stony. I examined this boiler after six weeks' use of your preparation, and found that the greater part of the incrustation had been dissolved or reduced to a state of powder. On washing some of the plates, the iron is plainly visible, and I am of opinion that the whole of the scale will be removed in course of time. I have not seen so marked an action with any other composition, and am much pleased with it, especially as I have looked for action on the iron, and found none whatever." Another firm writes that "it does not injure the slides or brass fittings of the engine." Upon this latter point—the action of the preparation upon metal—we recently had a conversation with an eminent analytical chemist. This gentleman assured us that, after some months of varied and searching experiment, he could not detect the slightest signs of injurious action upon any of the metals which he had subjected to its influence under the most trying conditions. These highly favorable results, together with those no less favorable which are vouched for in practical working, lead us to predict that Mr. Smith's composition will come into general use, and will prove of the highest value to steam users.—*Mechanics' Magazine.*

Cleaning Water Reservoirs.—There is no class of works which requires more careful attention during their progress than those relating to the supply, service, and storage of water. They are specially intended to deal with a most treacherous element, and should there be a weak point in any part of them, it will most undoubtedly be discovered before they have been many months in use. The large reservoirs necessary for the storage of the water supply of a town, are the most prominent items of those engineering enterprises termed water works. As might be anticipated, they must not only be kept in thorough repair, but they require occasional cleansing to maintain their contents sweet and wholesome. As there are generally two or three separate reservoirs in the same locality, the easiest plan of effecting their cleansing and the removal of any foul deposit that may have settled along the bottom is to run them dry by turns, and accomplish it by manual labor. It is nevertheless not difficult to understand that an instance might arise where it would not be possible to run the reservoir dry. There might, in fact, be only one reservoir, or the company might have so little storage space to spare, that it could not afford to employ this plan. Lastly, the supply of water might be so scant as to forbid, on that score, the adoption of the method. This very difficulty of being unable to run off the water, and so expose the bed of the reservoir, has been encountered at Lyons, and so successfully contended against that a short account of the means adopted will be both interesting and instructive.

By virtue of their agreement, the company in question were obliged to supply to the town a quantity of water amounting per diem to 900,000 gallons. This quantity had to be filtered before passing into the basins or reservoirs leading into the pipes supplying the town—a process which demanded a large extent of superficial space. As this supply was drawn from the Rhine, the level of that river very materially affected the rate of delivery into the reservoir, and recently, in consequence of the low state of the river, it was necessary to build a new tunnel nearly a quarter of a mile in length, to obtain a sufficient quantity of water. For some time past the engineers of the company remarked that the infiltration process did not proceed with its usual activity, and that the level of the river being constant, and also the surface of infiltration, the quantity of water arriving in the reservoirs was seriously diminished. Upon making an examination into the cause of this diminution, it was ascertained that the gravel at the bottom was overlaid with a thick white deposit of a marly-looking substance, bearing a strong resemblance, as far as appearance went, to white vitriol. This deposit came from the masonry of the reservoirs, which was all set in cement and hydraulic lime, and after attaining a certain thickness, opposed a very considerable resistance to the passage of the water. The problem to solve was, the removal of the deposit without disturbing the superincumbent liquid, or interfering with the constant supply, and the following means were adopted: A couple of pumps were set in operation by a portable engine. At the extremity of the tubes of these pumps was fixed a small apparatus, measuring about four square feet, which was open, and allowed to penetrate to the depth of a few inches in the gravel. The depth of the penetration was regulated, so that no very large quantity of water should be drawn up by the pump, but only sufficient to assist the removal of the deposit, and a little of the finest sand which came with it. The deposit separated itself from the gravel, and was removed without leaving any trace of the operation or disturbing the purity of the water.—*Building News.*

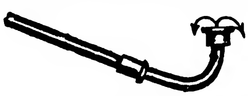
There has been much difference of opinion among engineers as to whether the pressure in a steam boiler was greatest at the top or bottom. Many have contended that the pressure was several pounds less at the bottom, although no good reason could be given for this theory, while others have maintained that the pressure was greater at the bottom, from the fact that the weight of water must be added to the indicated pressure of steam. We had the pleasure of seeing this question definitely settled a few days since at the Print Works of Messrs John and James Hunter, Hestonville, Penn. An elbow was put on the end of the blow-off pipe which entered the mud-drum. Into this elbow a plug was screwed, which was tapped to receive a half-inch pipe; to this pipe a steam gauge was attached and the blow-off cock opened. On comparing the gauges attached at the top of the boiler, and to the mud-drum as described above, it was found that the pressure was greatest at the bottom by some pound and a half, thus proving the latter theory, that the pressure at the bottom is, the indicated pressure plus the weight of the column of water.—*Locomotive.*

SIPHON DISCHARGE.—Mr. E. T. D. Myers, C. E., of Richmond, in a letter referring to the article from the "Journal of the Franklin Institute," published in our November number, detailing the difficulties in the use of a large siphon, says:

"It has come in the way of your correspondent to avail himself of a similar appliance, on two occasions.

"In the first instance the lift was about 20 ft. and the length 125 ft.; in the second, 10 ft. lift and 350 ft. long.

"4 in. pipes, with ordinary bell and spigot joints, caulked with lead, were used for both siphons. The inlet and outlet were provided with stop-cocks, such as are used upon street mains. There were two ordinary brass stop-cocks, tapped into the pipe at the summit. Both were opened while filling the pipe with water. There was no air chamber, but the lower end of the siphon was turned up thus:



the discharge taking the form of a low jet, and forming a 'trap' for the external air.

"I think that the omission of this trapped outlet will always lead to the trouble experienced at the Blue Ridge; yet I am not aware that it has been adopted save in the above mentioned cases.

"A word as to the lead joints. Unless the main be subjected to great variations of temperature, they may be relied on under pressures far exceeding those encountered in the siphon. The writer has himself tested the joints of 12 in. pipes, in the hydraulic press, up to 360 sq. in. lbs., and has found a longitudinal strain of 20 tons insufficient to tear such pipes asunder at the joints.

"Let any one form a girder of three such pipes united at the joints by lead, well caulked, and he will be surprised at its stiffness.

"The discharge of the Blue Ridge siphon is stated at 43½ gallons per minute. This is in close accordance with the formula given by Prof. Rankine. 'Civil Engineering,' p. 685, which give 42¾ gallons.

"M. Darcy's formula (vide Fontaines publiques de Dijon) for old and rusted pipes, translated from metrical measures into ours, will be as follows:

$$V = 40.20\sqrt{\frac{DH}{L}},$$

in which all dimensions are in feet and V= feet per second. The result with this formula would be still less, viz., 40 gallons.

VAN NOSTRAND'S ECLECTIC ENGINEERING MAGAZINE for December, closes the first year of that valuable work. The promises of the publishers have been more than kept, and we have reason to know that their anticipations of success have been fully realized. It is, emphatically, "an abstract and brief chronicle" of whatever is useful in the science of engineering, and of what is going on in the field of current operations. A glance at the table of contents of the volume (published with this No.) is in a sense a summary of these vast complex sciences and interests, and enables one to realize the outlay of labor and discrimination which such a publication demands. The table is, in a word, a lexicon of more than 400 different topics, many of which have been treated under from two or three to fifty sub-heads. To take a few examples alphabetically:—Bessemer steel and process is treated in 16 different articles, under as many heads: Blast Furnaces, 34; Boilers, 35; Bridges, 33; Cars, 38; Engineering Architecture, 16; Iron, 104; Ordnance, 51; Permanent Way, 22; Rails, 48; Railways, 177; Ships, 30; Steam-Engines, 29; Steel, 72; Tunnels, 16. It is announced that the size of the Magazine will be increased the coming year by the addition of 16 pages.—*Chicago Railway Review.*

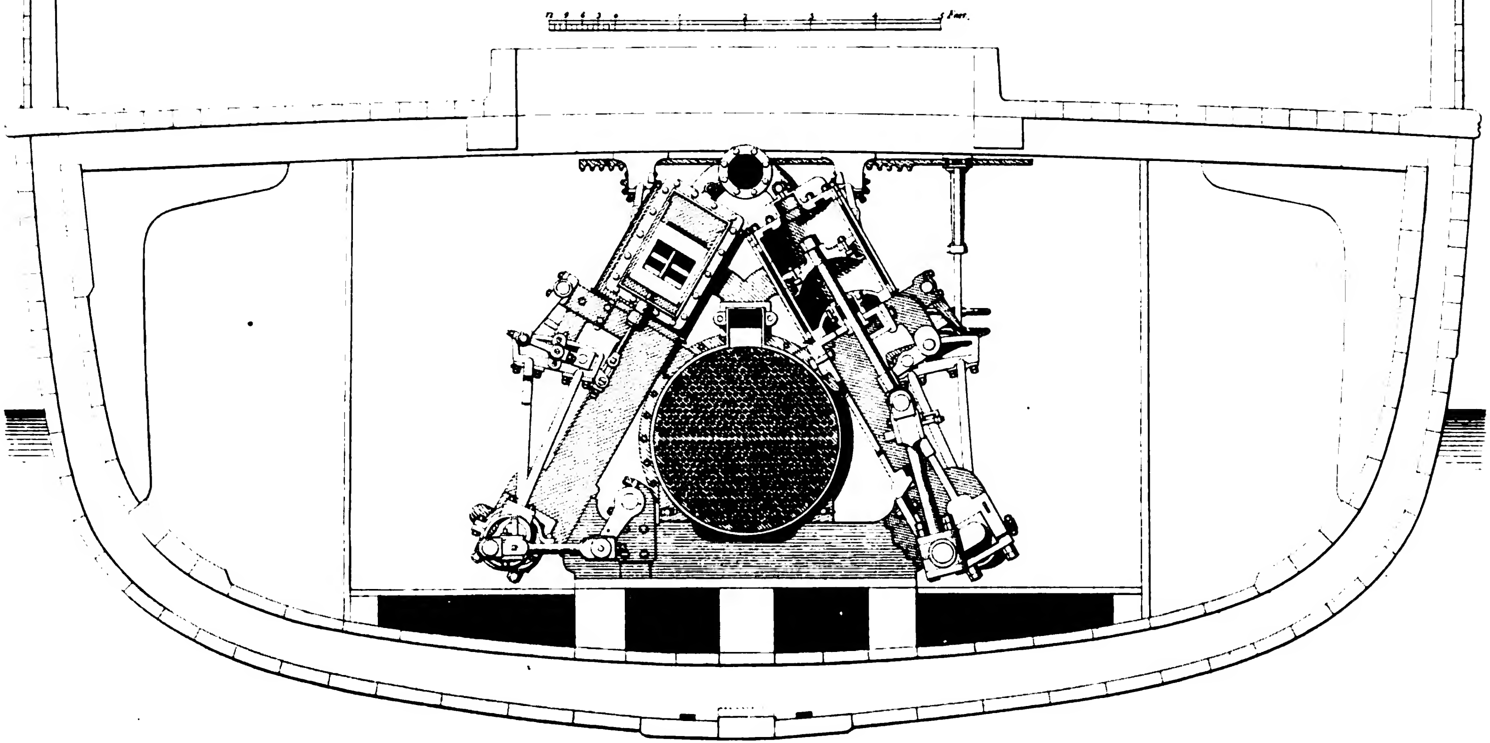
PRESERVATION OF STONE BY THE USE OF THE BLACK OXIDE OF COPPER AND ITS SALTS.—Dr. Robert, in "Les Mondes," argues to prove that the decay of all natural building stones is effected by various causes, and that among these a very minute lichen, *Lepra antiquitatis*, is one of the worst enemies of the stone; and this to such an extent that, for instance, the beautiful marble sculptures of the well-known Parc de Versailles will, unless proper measures are taken for staying the process of decay, become unsightly and ugly masses of dirt, and quite irretrievably lost as works of art within another fifty years. He instances such buildings at Paris as the Bourbon Palace, the Palais du Corps Legislatif, the Mazarin Palace (l'Institut), the Mint, and others, and points out that dust, spiders' webs, and the action of rain combine, with the minute lichen above alluded to, to call forth the decay of stone, especially of such parts, first, where any sculpture or ornamental carving promotes the deposition of dirt and dust. He argues by examples which every one can see, and which, moreover, are important, in consequence of the length of time which has elapsed since the protective action of the black oxide and salts of copper commenced, that the action of the two last-named substances is preservative to stone. In reference to granite, he states, adducing Waterloo Bridge as an example, that this stone is also, according to the experience of Egyptian engineers, far more readily affected by a moist climate than one would be led to believe. The obelisk of Luxor, brought from Upper Egypt to Paris, has become blanched and full of small cracks during the forty years it has stood on the Place de la Concorde, while forty centuries had not perceptibly affected it as long as it was in Egypt. Granite, in a moist clime, becomes the seat of a microscopically small cryptogamic plant, which greatly aids destruction; and it is, moreover, a well-known fact that the disintegration of stone, consisting of three separate minerals (quartz, mica, and felspar), depends very greatly upon the thorough and intimate mixture, as well as upon the chemical composition of the same, each of these minerals, separately, being readily enough weathered.—*The Building News.*

THE revival of the Merchant Marine is engaging the earnest attention of the Chamber of Commerce and press of New York. The "N. Y. Times" holds that in order ever to get back to where we were in 1860, we need to get rid of our high tariffs; to help our shipbuilders by admitting the raw materials they need, free from duties; in due time to allow our merchants to buy ships where they can buy them cheapest; and especially to open new and irresistible conduits of commerce, like the Darien Canal, before counting on the control of Chinese or Asiatic commerce.—*Chicago Railway Review.*

ENGINES FOR TWIN SCREW SPANISH GUNBOATS

Constructed at the Delamater Iron Works, New York,

from the designs of Capt. John Ericsson.



Engraved for Van Nostrand's Engineering Magazine 187[illegible]

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THE SPANISH GUNBOATS.

From the "Army and Navy Journal."

The annals of naval construction probably furnish no instance of greater diligence than that displayed in the production of the thirty Spanish gunboats now floating on the Hudson. The planning having been intrusted to Captain Ericsson, the contract for building the fleet was entered into with the Delamater Iron Works, in this city, on the 3d of May, 1869. On the 19th of May the first keel was laid, and on the 23d of June the first vessel was launched from Pouillon's shipyard, 34 working days after laying the keel. September 3d, just four months from the signing of the contract, and three months sixteen days after laying the first keel, the last vessel of this fleet was launched, at which time fifteen of the vessels previously launched had engines and boilers on board! Captain Rafael de Aragon of the Spanish navy, under instructions from Admiral Malcampo, the naval commander of the Spanish-Cuban fleet, superintends the equipment. Captain Aragon is favorably known in hydrographical circles for his accurate surveys of the Cuban coast.

The Spanish gunboats are sea-going twin-screw vessels, 107 ft. long on the water-line, 22 ft. 6 ins. extreme beam, 8 ft. depth of hold, and draw 4 ft. 11 ins. when fully equipped for service with coal, stores, and ammunition for 100 rounds on board. The lines at the bow are somewhat full in order to sustain a heavy bow-gun, the breadth of the deck being carried well forward for the purpose of facilitating the manipulation of this gun—of which we will speak presently. The run is very clean, the lines being deemed faultless for a twin-screw vessel. The construction of the hull presents two novelties worthy of special mention. The apparently insoluble character of the problem—a gunboat of this class drawing only 59 ins. of water when fully equipped for service—compelled the designer to dispense with the keel. Shipbuilders, it appears, at first objected to this innovation, but now admit that these gunboats may take ground with far less risk of straining and leaking than ordinary light-draught vessels with weak keels. The other novelty alluded to is the cutting down the rail and substituting a low, heavy timber bulwark at the bow, provided with substantial waterways and lined with sheet-iron to admit of firing the gun *en barbette*.

In addition to their ample steam power, the Spanish gunboats carry full amount of canvas, being schooner-rigged, with yard and square-sail on the foremast. Wire rigging having been adopted and the masts and smoke-pipe raked more than usual, the appearance of these twin-screw vessels is peculiarly light and saucy. Considering their great number, swiftness, light draught, and the long range of their guns, it is evident that the Spaniards will be enabled for the future to prevent

effectually, incursions on the Cuban coast.

As might be expected, the *steam machinery* of these novel war-vessels presents features of special interest. It has frequently been urged as an objection against the twin-screw system, that the double set of engines, four steam cylinders, with duplicates of all their working parts, called for on this system, render the whole too complicated and heavy for small vessels; preventing at the same time the application of *surface condensation.* The designer has overcome these objections by introducing a surface condenser, which, while it performs the function of condensing the steam to be returned to the boiler in the form of fresh water, serves as the principal support of the engines, dispensing entirely with the usual framework. Besides this expedient, each pair of cylinders have their slide-frames for guiding the movement of the piston rods, cast in one piece. Altogether, the combination is such that the total weight and the space occupied by these novel twin-screw engines do not exceed the ordinary single-screw engines of equal power. Several improvements connected with the working gear have also been introduced. The outer bearings of the propeller shafts, always difficult to regulate and keep in order on the twin-screw system, are self-adjusting and accommodate themselves to every change of the direction of the shafts. This is effected by their being spherical externally, and resting in corresponding cavities in the stern braces or hangers. The "spring bearings," for supporting the middle of the shafts, are also arranged on a similar self-adjusting principle. The thrust bearing, which receives the pressure of the propeller, is a peculiar construction, the arrangement being such that the bearing surfaces remain in perfect contact, however much the shaft may be out of line. The reversing gear, likewise, is quite peculiar, insuring complete control over the movement of the two propellers under all circumstances. It is claimed that these engines are the lightest and most compact yet constructed for twin-screw vessels.

The internal arrangements and fittings show thorough knowledge and experience on the part of the superintending officer. Our friends on the Baltic who pride themselves on knowing more about gunboats than other nations, will be astonished when they learn how the Spaniards fit out such vessels. Indeed the equipment more resembles that of a yacht than that needed for a plain gunboat. We cannot afford space for a specification, and therefore proceed to notice only that which is essential. The coal bunkers are placed on each side of the boiler, extending equally forward and aft of the centre of displacement of the vessel, in order to preserve perfect trim whether the bunkers are full or empty. The magazine, located in the centre of the vessel between the engine-room and the officers' quarters aft, is lined with lead on the inside, with the unusual precaution of having the outside protected by sheet-iron. There are three distinct modes of flooding this magazine, viz.: from the sea, by a powerful hand-pump, and by the donkey-engine pump. A small armory is arranged between the magazine and the cabin, containing thirty Spencer carbines, thirty Spencer pistols, and an equal number of cutlasses and dirks, the latter being accessible only from the cabin. In addition to the ordinary water tanks, a "fresh water maker" of ample capacity is provided, in which the condensation of the steam is effected by the current of sea-water which passes through the surface condenser; the fresh water being drawn off through a bent pipe on deck. A combined capstan and windlass of novel construction sufficiently low to fire over, is bolted to the deck over the chain locker at the bow; the combination being such that the capstan may be used alone, or one or both anchors raised at the same time. The quarters of the crew are arranged between the forward boiler, bulkhead, and the shell-room, which is situated under the bow-gun. Two large ventilators, with swinging tops, are applied for supplying the berth deck with fresh air. The shell-room is divided into several compartments provided with convenient shelves lined with zinc; separate lockers being arranged for storing ammunition for small arms. The shells are not, as customary in our Navy, contained in rude boxes strapped with iron. Each shell is placed in a well finished box provided with a sliding lid and rope handles, for convenient handling—a great improvement, as the shells may be taken out quickly and without being jarred. We will close our hasty description by mentioning that the wire

shrouds and smoke-pipe braces are provided with turnbuckles, by means of which, setting up and adjustment may be effected at any time by a single hand. Each gunboat is provided with two cutters and a yawl, all provided with a complete suit of masts, sails and awnings.

Respecting the armament the following brief notice must suffice for the present: It consists of a 100-pound rifle gun placed at the bow—a Parrott rifle—but a very different weapon from that represented by the photographed fragments which embellish so many pages of General Gillmore's famous book. Briefly, it is an improved Parrott 100-pound rifle with wrought-iron hoops round the chamber, carried to within 3 ins. of the trunnion; the chase being increased to correspond with the increased strength attained by the extension of the re-enforce. The severe ordeal through which the improved gun has passed during recent trials at Cold Spring conducted by the Spanish officers promises so well, that no doubt this improved Parrott gun has a future.

To Captain Ericsson's new gun-carriage, on which the improved gun is mounted, one of the leading features of the Spanish gunboats, we have space for only a cursory notice. It will be inferred from what has already been stated that the intention is to fire over the bow and in line with the keel. For this purpose and in order to command a wide horizontal range, a circular platform of wood, surrounded by a brass ring of 12 ft. 6 ins. diameter, is bolted to the deck at the bow. The gunslide, composed of wrought-iron, provided with friction rollers at both ends, rotates round a pivot secured to the deck, in the centre of the said brass ring. The carriage is made of light wrought-iron plates and angle iron riveted together in such a manner as to insure great strength longitudinally as well as transversely. By means of an eccentric movement, controlled by a suitable handle, the compressor which connects the carriage and the slide may be tightened or relieved so quickly that detachment will be quite safe during rolling; hence the gun may be run in and out by the vessel's motion alone. To admit of the gun firing in a direct line with the keel, the ordinary jib-stay has been abolished, and in place, two separate stays attached to the timber bulwarks, one on each quarter. Under canvas, a temporary jib-stay is secured to a shackle bolted to the outside of the stem. By these expedients the gun will have an uninterrupted horizontal range of 240 degs.

The gunboat which was first finished made two trips to West Point, in September, the result being deemed highly satisfactory. The official trial did not, however, take place until October 25th. But for the disadvantage of a combined river and tidal current, the Hudson above Fourteenth street would offer an unequalled trial ground, the river being perfectly straight and running exactly at right angles with the streets. The ground selected for the trial trip was from Fourteenth street to One Hundred-and-Twenty-ninth street, a distance of 30,720 ft., or 5.81 statute miles. The run up the river against the tide occupied 32 min. 35 sec., the return trip being performed in 29 min. 35 sec. Total distance 11.62 miles, in 62 min. 10 sec. Considering the small size and necessarily full lines of these gunboats, the speed thus attained is remarkable. In open water out of the tidal river current, which so injuriously affects the propeller by a difference of speed at the upper and lower circumference, a higher rate will undoubtedly be attained. It should be stated that the vessel, during the trial, was loaded with pig-iron to her intended maximum draught.

A fleet of 30 war-vessels, precisely alike, being by no means an ordinary sight, a visit to Delamater's Works on the Hudson, where the saucy-looking craft are now stationed, ten abreast, cannot fail to be very interesting to naval men. It is a significant fact that this great display of offensive and defensive force is the result of the efforts of a single establishment, directed by individual skill. Evidence more conclusive could not be furnished, that the progress of the country and its resources are equal to any future emergency.

A VEIN of excellent coal has been discovered, extending along the line of the Kansas Pacific Railroad, east of Denver. This discovery shows that the workable coal beds of the Rocky Mountains extend miles eastward into the great plains, and is of the greatest importance both to settlers and to the railway company.

ON THE OUTFLOW OF STEAM.

By J. W. MACQUORN RANKINE, C. E., LL.D., F. R. S.

From "The Engineer."

1. Having been led, by careful consideration of Mr. R. D. Napier's researches on the outflow of steam, to the conclusion that the fundamental principle of his theory is substantially correct, I propose to show, in this communication, how that principle is to be used in combination with the expressions for the energy developed by expanding steam, which are deduced from the laws of thermodynamics.

2. In the first place, I will refer to the thermodynamic formula for the velocity of outflow of a perfect gas. If that formula is to be named after its first publisher, it should, so far as I know, be called "Weisbach's formula," and by that name I will denote it for brevity's sake throughout this communication.

It is quite true, as Mr. R. D. Napier has pointed out, that the ordinary method of using Weisbach's formula is based on the supposition that the pressure at the contracted vein or throat of the jet is the same as in the space into which the gas is discharged. That this supposition is realized in the case of air (and probably of other gases) issuing from a conoidal converging nozzle of the form of the contracted vein, with pressures in the air vessel ranging up to about double the external pressure, is proved by the experiments of Weisbach, in which the quantities discharged from such a nozzle agree practically with those given by the formula. But if by any means, such as the addition of a trumpet-shaped expanding discharge pipe to the nozzle, the pressure at the contracted vein were made to become different from that in the outer space, or if the jet were to spread of itself after issuing from the orifice, and if the pressure were not to become equal to the outside pressure until the sectional area of the jet had become greater than that of the throat, it is evident that results very different from those commonly deduced from the formula would be obtained. The formula, however, might be made applicable to such cases, supposing friction to be insensible, by taking for the effective area of outlet, not that of the throat of the nozzle, but the transverse area of the jet at the place where its pressure first becomes equal to that in the outer space.

3. In the experiments of Weisbach the outside pressure, being always that of the atmosphere, was not varied to any material extent; and therefore the circumstances were not adapted to show directly the existence of a maximum in the *mass* discharged with a constant inside pressure and a variable outside pressure. The only experiments I knew of which directly show such a maximum are those of Thomson and Joule. Of course there can be no such intermediate outside pressure corresponding to a maximum in the *velocity* of discharge, which must increase with every diminution of the outside pressure; although there is a limit to the increase of that velocity when the outside pressure becomes inappreciably small.

4. It appears from Weisbach's experiments that, in order that the formula may give correct results with a constant coefficient of discharge, it is necessary that the nozzle should in every case have an entrance resembling the contracted vein. For example, in the following cases the co-efficients of discharge may be considered as practically constant.

Coefficient of discharge:—Conoidal nozzle of the form of the contracted vein, from 0.97 to 0.99. Short cylindrical tube, bell-mouthed at the inner end, from 0.92 to 0.93.

On the other hand, when the entrance to the nozzle is sharp-cornered, or when the outlet is simply a hole in a thin plate, the coefficients of discharge are irregular.

5. *General Formulæ for the Outflow of Elastic Fluids.*—The following formulæ for the outflow of elastic fluids have long been well known. Let p_1 be the absolute pressure inside a vessel, such as a boiler, and p_2 the absolute pressure outside. Let U denote the work done by an unit of weight of the fluid employed, if admitted into a cylinder at the pressure p_1, expanded till the pressure falls to p_2, and expelled at the latter pressure. Then the final velocity with which the fluid will

escape from an outlet in that vessel will be given by the following formula :—

$$v = \sqrt{(2\,g\,U)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

g denoting gravity.

Let s_2 be the volume of the space occupied by unity of weight of the fluid in the escaping jet at the instant when its pressure becomes equal to the external pressure p_2 ; then the weight of fluid which escapes per second through each unit of *effective area* of outlet is expressed as follows :—

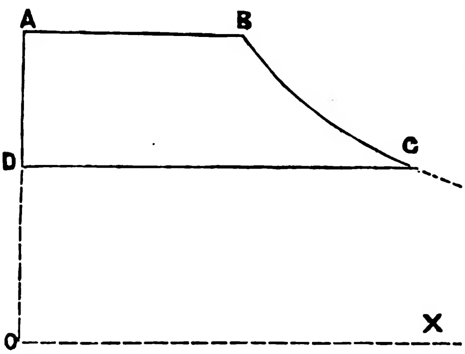
$$m = \frac{v}{s_2} = \sqrt{\frac{(2\,g\,U)}{s_2}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

I will call this for brevity's sake the *mass-velocity*.

6. The general formula for the quantity of work U, in all cases whatsoever, is as follows :

$$U = \int_{p_2}^{p_1} s\,dp \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where s is the volume occupied by unity of weight of the fluid when its pressure is p. The quantity of work U may be represented by the area of a diagram such as A B C D ; where A B represents



s_1, the initial volume, and D C represents s_2, the final volume, of unity of weight ; D A represents $p_1 - p_2$, the total fall of pressure ; and B C is the expansion curve. The zero line of absolute pressure is represented by O X. It is evident that the mass-velocity

$$m = \sqrt{\frac{2\,g\,U}{s_2}} = \sqrt{\frac{2\,g\,.\ \surd\,(A\,B\,C\,D)}{D\,C}}$$

varies proportionally to the square root of the ratio which the area A B C D bears to a square described on D C as a base, which ratio is equal to the ratio that the mean height of the line A B C above D C (which mean height represents the mean effective pressure) bears to D C. This mode of viewing the matter makes it easy to understand how it is that for a given inside pressure there is a certain outside pressure which makes the mass-velocity a maximum. For, on the one hand, when D C is very near to A B, the rate in question becomes very small through the smallness of the effective pressure ; and, on the other hand, when D C is very near to O X the same ratio becomes again very small through the great increase of D C ; so that the greatest value of that ratio must be given by some intermediate position of D C ; and this holds for every known law of expansion. The way in which the volume s varies with the pressure p depends on the nature and condition of the fluid, and the circumstances in which it is placed as to transfer of heat.

Although the pressure denoted by p_2 in the preceding formulæ is equal to that in the outside space, the corresponding volume of unity of weight of the fluid in the jet s_2 is *less* than the volume ultimately assumed by the same mass when it comes to a state of rest ; for the extinction by friction of the motion of the jet causes the temperature of the quiescent external fluid to be higher than that of the escaping jet.

When steam which, though saturated, is *dry inside the boiler*, escapes through an outlet, the exact formulæ for the mass-velocity under different circumstances as to transfer of heat, and the approximate formulæ, which may be substituted for those exact formulæ, give results whose differences from each other are not of much importance in a purely practical point of view. But when the steam within the boiler is misty, and holds liquid water in suspension, the results may differ very widely from those for dry steam. In any case, it may be instructive to compare together the several formulæ, exact and approximate, for the work U and the volume s_2 under different circumstances.

7. *Steam Gas.*—For steam superheated to such an extent as to be sensibly in the perfectly gaseous state, both before and during its expansion, if it escapes without receiving or giving out heat, the proper formula is that of Weisbach, already referred to, with the value 1.3 for the index of the power of the density to which the pressure is proportional. Examples of

the results of this formula, calculated by Mr. Baldwin, have already been given in "The Engineer."

8. *Saturated Steam, with a Non-Conducting Nozzle.*—The exact thermodynamic formula for the quantity of work denoted by U, when steam free from moisture expands without transfer of heat, was independently investigated by Clausius and myself, and published by me in a paper read to the Royal Society in 1853, and printed in the "Philosophical Transactions" for 1854, and by him in lectures delivered orally in 1854, and in a paper in "Poggendorff's Annalen" for 1856. It is as follows:

$$U = J \left\{ t_1 - t_2 - t_2 \text{ hyp. log. } \frac{t_1}{t_2} \right\} + \frac{t_1 - t_2}{t_1} H_1 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In which J denotes Joule's dynamical equivalent of a degree of heat in liquid water, being 772 ft. per degree Fahr., or 424 metres per degree Centigrade; t_1 and t_2 are the absolute temperatures corresponding to the pressures of saturation p_1 and p_2 respectively; and H_1 is the dynamical equivalent of the latent heat of evaporation of an unit of weight of water at the higher pressure. The value of H_1 is given to a close approximation by the formula

$$H_1 = a - b\, t_1 \quad . \quad . \quad . \quad . \quad . \quad (4\text{A})$$

in which a=1,109,550 ft., or 338,191 metres; and b=540 ft. per degree of Fahr., or 297 metres per Centigrade degree; and thus the value of U is made to depend on the two temperatures t_1 and t_2 alone.

The steam partially condenses during the expansion; and the liquid water thus formed is re-evaporated through the heat produced when the motion of the jet is extinguished by friction. The volume s_2 to be used in calculating the mass-velocity is that of the moist steam at the end of the expansion, and its value is as follows:

$$s_2 = \frac{d\,t_2}{d\,p_2} \left(J \text{ hyp. log. } \frac{t_1}{t_2} + \frac{H_1}{t_1} \right) \quad . \quad . \quad . \quad (5)$$

in which $\frac{d\,t_2}{d\,p_2}$ denotes the rate of variation of temperature with pressure of saturation at the lower limit of pressure.

By comparing the volume s_2 given by the formula, with the volume of unity of weight of dry saturated steam at the pressure p_2, the proportion of steam temporarily liquefied may be calculated.

The equations 4 and 5 were originally demonstrated with a view to their employment in calculating the work of steam in steam-engines. Zeuner was the first (so far as I know) to apply them to the question of the outflow of steam, which he did in a paper entitled "Ueber den Ausfluss von Daempfen und hocherhitzten Fluessigkeiten aus Gefaessmuendungen," published in the "Civilingenieur" for 1864, vol. x. part 2. The following are examples of results calculated by him. The mass-velocities of outflow are given in kilogrammes per second per square metre of effective area of outlet; and I have added the corresponding values in pounds per second per square inch of effective area. The external pressure in each case is that of the atmosphere.

Internal absolute pressure, Atmosph's	Velocity. Metres per second.	Mass-velocity. Kilogs. per sq. metre per second.	Mass-velocity. Pounds per sq. inch per second.
1	0	0	0
2	481.72	304 83	0.434
3	606.62	393.15	0.559
4	681.56	449.28	0.639
5	734.42	490.53	0.698
6	775.00	523.22	0.744
7	807.85	550.12	0.783
8	835.00	573.25	0.815
9	858.41	593.89	0.845
10	878.92	611.16	0.869
11	896.87	627.18	0.892
12	913.05	641.73	0.911

Within the limits of pressure that are usual in practice, the density of originally dry saturated steam when expanding in a non-conducting cylinder varies nearly as the ninth power of the tenth root of the absolute pressure, and therefore the following approximate formulæ may be used instead of equations 4 and 5:

$$U = 10\, p_1\, v_1 \left\{ 1 - \left(\frac{p_2}{p_1} \right)^{\frac{1}{10}} \right\} \quad . \quad . \quad (6)$$

$$s_2 = s_1 \left(\frac{p_1}{p_2} \right)^{\frac{9}{10}} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

9. *Outflow of Superheated Water.*—The following expressions for work done in driving a piston in a non-conducting cylinder by an unit of weight of water admitted into the cylinder while wholly in the liquid state, and for the volume to which that water ultimately expands by

partial evaporation, were investigated independently by Clausius and myself, and first published in the two papers already referred to.

$$U' = J\left\{t_1 - t_2\left(1 + \text{hyp. log.}\,\frac{t_1}{t_2}\right)\right\}[+l(p_1 - p_2)] \quad (8)$$

$$s'_2 = \frac{d\,t_2}{d\,p_2}\left(J\ \text{hyp. log.}\frac{t_1}{t_2} = \frac{H_1}{t_1}\right)[+l] \quad . \quad (9)$$

in which l denotes the volume of unity of weight of liquid water, and the other symbols have the meanings already explained in article 8.

In my own application of these formulæ the terms enclosed in square brackets [ ], which depend on the volume l of the water when in the liquid state, are neglected, as being practically inappreciable. In Zeuner's calculations those terms are taken into account for the sake of greater precision. In fact, the terms in square brackets ought to be inserted in the equations 4 and 5, in order to give absolute precision.

The formulæ 8 and 9 (subject to the preceding explanations) were applied to the outflow of superheated water from a boiler by myself in the "Philosophical Magazine" for December, 1863, and by Zeuner in the paper already referred to, published in the "Civilingenieur" for 1864. The results of the calculations of both authors give for the mass-velocity of superheated water escaping into the atmosphere from a boiler in which the internal absolute pressure ranges from two to twelve atmospheres, values differing little from 1120 kilogrammes per second per square metre of effective area, or very nearly 1.6 lbs. per second per square inch of effective area.

10. *Outflow of Mixed Water and Steam.*—Clausius was the first to combine the expressions 4 and 5 with the expressions 8 and 9, so as to obtain the values of the work done in a non-conducting cylinder, and of the final volume assumed, by a mixture of steam and liquid water in given proportions. In each unit of weight of the mixture let f be the fraction that is in the liquid state, and $1-f$ the fraction that is in the vaporous state at the beginning of the expansion. Calculate U and s_2 as for steam, by equations 4 and 5, and U' and s'_2 as for superheated water, by equations 8 and 9; then the mass-velocity is

$$m = \sqrt{\frac{2g.\surd\{(1-f)U + fU'\}}{(1-f)s_2 + fs'_2}} \quad . \quad (10)$$

11. *Outflow of Saturated Steam kept dry.*—If we suppose the steam to escape through a conducting nozzle, from which it receives just heat enough to prevent any liquefaction, the value to be taken for U is that of the work done by an unit of weight of dry saturated steam in a jacketed cylinder. The only original investigation of the exact value of that quantity of work, with which I am acquainted, is that contained in a paper of mine which was received by the Royal Society in December, 1858, and printed in the "Philosophical Transactions" for 1859, page 177. The formula is as follows:—

$$U = a\ \text{hyp. log.}\,\frac{t_1}{t_2} - b\,(t_1 - t_2) \quad . \quad . \quad . \quad (11)$$

in which t_1 and t_2 are, as before, the absolute temperatures corresponding to the inside and outside pressure respectively; and a and b are the coefficients already given in the formula for the latent heat of steam; viz., a = 110955 ft. = 338191 metres; b = 540 ft. per degree of Fahr., or 297 metres per Centigrade degree.

The value of s_2 is simply the volume of unity of weight of dry saturated steam at the pressure p_2, that is to say

$$s_2 = \frac{d\,t_2}{d\,p_2}\left(\frac{a}{t_2} = -b\right) \quad . \quad . \quad . \quad . \quad (12)$$

Tables and diagrams have been published, from which the values of U and of s_2 can easily be found.

In the paper just cited it was shown that within the limits of pressure which are usual in practice, the density of dry saturated steam varies nearly as the sixteenth power of the seventeenth root of the absolute pressure; hence the following approximate formulæ may be used:—

$$U = 17\,p_1\,v_1\left\{1 - \left(\frac{p_2}{p_1}\right)^{\frac{1}{17}}\right\} \quad . \quad . \quad . \quad (13)$$

$$s_2 = s_1\left(\frac{p_1}{p_2}\right)^{\frac{16}{17}} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

12. *Mr. R. D. Napier's first Formula* gives results whose differences from those of Zeuner's calculations are immaterial in practice so long as the internal absolute pressure does not exceed twice the external absolute pressure. It has been shown by Weisbach (Civilingenieur, 1856) that a formula resembling that of Mr. Napier, though not quite identical with it, gives a value of the velocity of outflow of air about 2½ per cent. greater than that given by the exact thermodynamic formula when the external pressure is twice the external

pressure. It is obvious that the simplicity of Mr. Napier's formula is a great advantage in calculations for practical purposes.

13. *Effective Area of Outlet.*—When the external pressure does not exceed about twice the internal pressure, it appears, from the experiments of Weisbach on air, and of Mr. R. D. Napier on steam, that the effective area of outlet is sensibly that of the contracted vein or throat; that is, for a tapering conoidal nozzle, an area very little less than that of the narrow end of the nozzle, and for a short cylindrical tube from .9 to .8 of the transverse area of the tube, according as the entrance to it is rounded or not at the inner end.

Zeuner, near the end of the paper already referred to, considers it probable that the effective area of the jet is in general *greater* than the actual transverse area of its throat or narrowest part, in a proportion depending partly on the form of the outlet and partly on the pressure. He makes no attempt to determine from theoretical principles what laws that proportion may follow, and states that those laws are to be ascertained by experiment only.

The experiments of Mr. R. D. Napier are to be considered as forming an important step towards the determination of those laws. The following table shows some examples of the calculation of the ratio of the effective area of the jet to that of its throat, or *coefficient of extension*, as it may be called, based on a comparison of the results of Mr. Napier's *second* formula (regarded as representing his experiments empirically) and those of Zeuner's calculations already referred to.

External pressure, 1 atmosphere.
Internal pressure, atmospheres,
2 3 4.
Mass-velocity in kilos. per square metre per second (Zeuner),
304 393 449.
Discharge in kilogrammes per second per square metre of throat of jet (Napier),
316 478 632.
Co-efficient of extension,
1.04. 1.22. 1.41

Experiments on the outflow of steam should be made with nozzles of the form of the contracted vein, opening at once into large receivers, or into the atmosphere ; for thus are obtained values of the coefficient of extension when freed from the effects of special forms of outlet. That the effects of such forms may be very great will at once appear when it is considered that in an outlet having a conoidal converging part at the inner end, a narrow throat, and a gradually diverging trumpet-shaped part at the outer end, the effective area (subject to certain limitations which it is unnecessary here to state in detail) is well known to be situated, not at the narrow throat, but at or near the wide mouth. This, in fact, is one of the essential principles of the action of jet pumps, injectors, and ejectors. Even when the widening towards the mouth takes place abruptly, as when a narrow cylindrical tube is followed by a wide one, the effective area is not that of the narrow tube, but is intermediate between the area of the narrow tube and that of the wide tube. Such appears to have been the construction of the apparatus employed by Mr. Napier in an experiment described in his letter which appeared in "The Engineer" of the 1st of October, 1869. The mass-velocity, calculated theoretically from the pressures, is about 22 lbs. per minute per square inch of effective area ; the discharge per minute was 13 lbs.; therefore the effective area was about 0.6 of a square inch. The transverse area of the narrow pipe was 0.246 of a square inch ; that of the wider pipe, between 0.785 and 1.23 square inch. Hence it appears that the effective area of the jet was intermediate between those of the throat and of the mouth of the outlet tube.

14. *Maximum Mass-Velocity.*—Mr. Napier's second formula may be regarded as approximating to the results of the supposition, that when the outside pressure falls below that which corresponds to the maximum mass-velocity, the coefficient of extension adjusts itself in such a way that the pressure corresponding to the maximum mass-velocity is still maintained at the throat of the jet ; a supposition not improbable in itself, and confirmed, at all events approximately, by Mr. Napier's experiments so far as they have gone.

In order to determine the consequences to which this theory leads when applied to the more exact formulæ for the work done by steam in expanding, it is to be observed that if the absolute pressure varies nearly in proportion to that power

of the density whose index is n, the greatest mass-velocity is attained when the pressure at the throat, or narrowest part of the outlet, bears the ratio to the internal pressure which is expressed by the following fraction :

$$\left(\frac{n+1}{2}\right)^{\frac{-n}{n-1}}$$

The following are examples of the value of that fraction :

$$\begin{array}{rccccc} n = & 1 & \frac{1}{16} & 1\frac{1}{9} & 1.3 & 0.408 \\ \left(\frac{n+1}{2}\right)^{\frac{-n}{n-1}} = & \frac{3}{5} & 0.5968 & 0.5823 & 0.5457 & 0.5269 \end{array}$$

The last of these values approximates nearly to $\frac{1}{2}$, being the value assumed by Mr. Napier.

It has already been stated that when dry saturated steam is supplied during its expansion with heat just sufficient to prevent liquefaction, the value of n is $1\frac{1}{16}$ nearly; hence the absolute pressure in the throat of the outlet corresponding to the greatest mass-velocity is very nearly 0.6 of the absolute internal pressure. The following table shows some examples of maximum mass-velocities calculated according to those principles, expressed in *pounds per square inch of throat of outlet per second;* and compared, first, with the results of Mr. Napier's second formula as shown by his Table, and, secondly, with those of a formula found by trial, and which, although it gives a very rough approximation, is convenient because of its great simplicity; it consists in taking *one-seventieth part of the absolute internal pressure on a given area* for the mass discharged through an equal area of throat.

Temperature, Fahrenheit	Absolute internal pressure—lbs. on the square inch.	Maximum mass-velocity—lbs. per sq. inch of throat per second.		
		Theoretical formula.	Mr. R. D. Napier's formula.	Rough formula.
212	14.70	0.219	0.232	0.210
239	24.54	0.360	0 372	0.351
248	28.83	0 415	0.440	0.412
293	60 40	0.860	0.901	0.863
329	101.9	1.433	1.490	1.456
356	145.8	2.025	2.185	2.083
419	305.5	4.144	4.700	4.364

The fourth of these examples, in which the absolute internal pressure is 60.4 lbs. on the square inch., and the theoretical mass-velocity per square inch. of throat is 0.86 lbs. per second, or 51.6 lbs. per minute, agrees very closely with Mr. Napier's experiment described in "The Engineer" of the 1st Oct., 1869, p. 228, col. 2.

15. *Conclusions.*—From the general agreement of the results of Mr. R. D. Napier's formulæ with those of his experiments, and of both with those of theoretical formulæ taken in combination with the supposition that the pressure at the throat of the outlet never falls below that corresponding to the maximum mass-velocity, it may be inferred that the following conclusions, if not absolutely proved, are at all events highly probable.

First. The pressure at the throat of the outlet never falls below that corresponding to the maximum mass-velocity of outflow, how low soever the external pressure may be; and, so far as I know, the merit of originally proposing and applying this principle belongs to Mr. R. D. Napier.

Secondly. A rule based on the combination of the preceding principle with thermodynamic formulæ and tables for the work of expanding steam, gives results nearly agreeing with those of Mr. Napier's experiments and of his second formula.

Thirdly. Mr. Napier's pair of formulæ give results which are good approximations for practical purposes.

Fourthly. As a rough approximation, the weight of steam discharged through a given area of *throat* may be taken as nearly equal to *one-seventieth* part of the internal absolute pressure on an equal area, when that pressure is not less than five-thirds of the external absolute pressure. When the internal absolute pressure is less than five-thirds of the external absolute pressure, calculate the outflow as if for an internal absolute pressure equal to five-thirds of the external pressure, and diminish it in a proportion expressed by the square root of the ratio, in which the actual difference of pressures is less than two-thirds of the external absolute pressure.

These rough rules are expressed in symbols as follows: Outflow in units of weight per unit area of throat, nearly when:

$$p_1 = \text{or} > \tfrac{5}{3} p_2 ;$$
$$\text{outflow} = p_1 \div 70 ;$$
$$\text{and when } p_1 > \tfrac{5}{3} p_2 ;$$
$$\text{outflow} = \frac{p_2}{42} \cdot \sqrt{\left\{\frac{3(p_1 - p_2)}{2p_2}\right\}}$$

THE PROPERTIES OF MALLEABLE CAST-IRON.

By Dr. Adolph Ott.

From the "Journal of Applied Chemistry"

The increased flexibility of malleable iron, according to Mr. R. Mallet, is to be attributed to the fact that small crystalline scales of graphite are uniformly disseminated through the mass of the iron. Indeed it is otherwise known that the most rigid materials become flexible when fibrous or scaly crystals of different natures are distributed through them; these latter may themselves form in flexible bodies when united to larger masses. The flexible Indian sandstone, for instance, consists of a mass of quartz crystals through which fibres of asbestos are uniformly disseminated; other kinds of flexible sandstones contain mica crystals in the quartz mass, as, for instance, the itacolumite, which, in Brazil, is regularly associated with the diamond. The flexibility of the respective bodies must in all these cases be ascribed to the property of the smooth crystals to change their relative position to each other, and, with regard to the mica scales in the sandstone, they behave like the graphite scales in the iron.

According to Pelouze and Fremy the specific gravity of malleable iron approaches very nearly that of cast-iron. Brull, as the result of three determinations, found the numbers 7.10, 7.25, and 7.35. The specific gravity of wrought-iron being from 7.6 to 7.8, we have another proof that malleable cast-iron is not identical with wrought-iron. The fracture of malleable cast-iron is very different from that of any kind of wrought-iron; it is darker and less brilliant, and lacks that fibrous aspect so characteristic of tough wrought-iron. It is similar to dark and ordinary pottery, but different from it in color and lustre. In forging, the aspect of the fracture becomes greatly altered, on account of the flexibility of the material, which sometimes requires considerable hammering before it breaks. The fracture of very carefully manufactured malleable iron appears on the average more like that of a very fine-grained, white cast-iron than that of wrought iron. In large pieces the fracture is uniform throughout. In filing, turning, and planing it works quite similar to wrought-iron, but the surface often appears somewhat whiter. Large pieces can seldom be well turned to a great depth. According to some statements, malleable iron is capable of taking a better polish than cast-iron, and it takes as good a one as cast-steel. It also holds a better lustre than many sorts of dark and impure wrought-iron, but the polish is inferior to that of good steel, as in razors of first quality, even the surface appears a little whiter. Good hard cast-iron may probably be polished as well. With regard to the hardness, reliable data are not procurable. Malleable cast-iron is generally very soft —softer than wrought-iron of any kind. It takes the impression of the hammer with a very slight blow, and wears off rapidly in contact with rough surfaces.

It is exceedingly porous, as may be expected from its small density. According to Brull, oil, when left in a cup of malleable iron, penetrates through it in a very short time; the correctness of this assertion, however, remains doubtful. Cast-iron bells are far more elastic than bells of malleable iron, producing also a higher and clearer sound.

Morin and Tresca have found that the elasticity of malleable cast-iron is considerably less than that of the most inferior wrought-iron. The absolute power of resistance is indicated by the latter as being thirty-five kilogrammes per square metre. Thin pieces, of a diameter not over one-quarter or three-eighths of an inch, may be bent while cold, without cracking; but they can rarely be restored to their original state without being partly or altogether fractured. However, the end of a rod may be forged till red hot, without a break or crack being produced; thin plates may safely be hammered into hollows, provided they are not too deep. Malleable iron will bear rolling to a small degree. All these manipulations bring about a closer grain, and a fracture similar to that of fine-grained steel-like iron. No instance is known where malleable iron has been drawn into wire; but this is possible, since it will bear a slight elongation, assuming thereby a finer grain. It may be pretty well forged at a low red heat, somewhat

above a cherry-red heat, but in endeavoring to beat it out, it tears and breaks to pieces. According to Mallet, this temperature, and that beneath a bright yellow heat, are those at which it may be best forged; but it is more than probable that various kinds act differently under the same circumstances. This peculiarity certainly deserves further attention, on account of the fact that various articles which have not, as yet, been produced from malleable iron, might advantageously be made from it in cases where the form of the cast piece might have to be altered afterward. When hammered at yellow heat, malleable iron falls to pieces, and large, not uniformly cemented pieces, appear in the interior.

It is clear that malleable iron cannot be welded properly; indeed, this is the case even if two pieces can be made to stick together, and the surface of contact be kept free from rust; it is self-evident that it cannot be welded with wrought-iron or steel, still it may be soldered with them by means of hard solder. With respect to the fusing point of this metal, it is a high one; it lays above that of gray or halved cast-iron, but probably not above that of many sorts of white or hard cast-iron, and certainly considerably below that of cast-steel. In the fire, malleable cast-iron is said to become more slowly oxidized than ordinary cast-iron. In France, the silver refiners use a large number of crucibles that are manufactured from that material, but no accounts exist of how much iron they leave to the silver. According to Brull, malleable iron can be tempered with the ordinary carboniferous cementing powders, as well as with prussiate of potassa. If watered when bright red hot, it may be tempered more or less; still the temper is always imperfect, not uniform, and quite different from that of good steel, but perhaps more perfect than that which wrought-iron assumes, when suddenly cooled. Still, correct statements are yet wanting with regard to this point.

REPAIRED BOILERS.

From "The Engineer."

The dangerous character of steam boilers which have been subjected to repeated mending is notorious to every engineer who has given even the slightest attention to the working of this class of machinery. His list of boiler calamities will contain many conspicuous records of serious disasters resulting from the incapability of many people who have had the practical oversight of boilers at ironworks, and collieries in particular, to detect when a boiler has been sufficiently patched. Those records will likewise strengthen him in his conviction that very many workmen to whom repairs are intrusted are altogether unfit for their duties.

There is hardly any operation connected with the repair of a boiler more productive of danger than that by which rivets are brought into a line. The day is gone by, we hope, when in new boilers the longitudinal seams are made to run in a continuous line from end to end, with the transverse seams also continued completely round the boiler, giving at the corner of each plate four thicknesses of iron. Yet unskilful repairs often produce continuous lines of rivets at the very place in a boiler where it is most desirable that there should be the brick-wall-like arrangement of the seams, which adds much to the strength, and also often prevents a rent from continuing forward to a dangerous point. A large externally fired tube boiler at an ironworks in Wolverhampton some time ago burst its shell. The first rupture took place in a seam over the fire, where frequent repairs had led to a considerable length of longitudinal seam, being in one continuous line. The four plates over the fire parted and opened out until they had ripped two seams completely round the boiler. The plates were thrown in one flat piece upon a bank behind, whilst the main body of the boiler, with the tubes, was turned over and the front end blown away. More recently, at Newcastle-upon-Tyne, a plain cylindrical boiler was much torn up, and all the fragments thrown to the front of their original position. The boiler was very old and much deteriorated, so that it was unable to bear the ordinary pressure, a longitudinal arrangement of the

plates contributing to the weakness. Shortly afterwards, in the same town, a similar boiler was much torn and scattered. Here, too, the plates had been arranged longitudinally, and the accident began at a patch lately put on. The boiler had become so deteriorated by nearly thirty years' wear, that it was not able to do the moderate duty required of it. Very quickly afterwards, at Durham, another plain cylinder, with plates longitudinally arranged, and which had been working twenty-seven years, gave way at an old fracture over the grate, and was torn into four pieces, which fell a great distance off; and on the 18th of October last a plain cylinder with round ends, 40 ft. long and 6 ft. diameter, made of half-inch plates, and set with a fire-grate at one end, and flash flue, exploded at the works of the Great Bridge Iron and Steel Company, in South Staffordshire. The front end, with three rings of plates, was thrown up to a sufficient height to clear the buildings, and fell into a pool some distance to the right and slightly to the rear, the remaining part of the boiler being left near to its original position. The boilers on each side were thrown off their seats, that on the left knocking down a new upright boiler which was nearly ready to work. The first rent appears to have taken place at a seam over the left side of the fire-grate, where four new plates and a long patch had been inserted. This rent must have instantly extended across the front of the man-lid above and around the fourth transverse seam, near some patches, thus allowing the shell to open out, the reaction of the issuing contents sending the fragments upwards. There were so many patches in the boiler, especially around the part which gave way, that many seams were made in continuous lines without any break of joint, and a great number of rivets must have been removed from some of the seams more than once, thereby very much reducing their strength. "I believe," said Mr. E. B. Marten, from whose evidence at the inquest last Friday we have been quoting, "the cause of the explosion was simply that this frequent repair had so reduced the strength of the boiler that it was unable to bear even the usual working pressure. It is often difficult," he adds, "to convince those who have the repair of boilers that the putting of patch upon patch reduces the strength of the boiler, until it is completely untrustworthy, although it may not leak; but several explosions this year, and very many in past years, have proved the fact beyond dispute. The great havoc caused by such an explosion as that now under investigation, leads many casual observers to suppose that they are caused by some sudden accession of force within the boiler; but the enormous force pent up within any high-pressure boiler is quite sufficient to account for all the mischief, when the balance of strain in the fabric is destroyed by the sudden giving way of a weak seam."

It is as true now as it was eighteen hundred years ago that an effectual way of destroying that which is old, is to patch it with that which is new. The danger is more in the patching than in the repairing. True, a boiler, any more than a garment, is not as strong after repair as when new, even though not a patch, but a new breadth be inserted; still the new breadth, properly put in, is much less likely to bring about destruction than the patch. Very little capital, and hardly more ability, is needed in the coal and iron districts to enable a man to pass muster as a "boiler maker." He should rather be termed a boiler mender. A portable forge, a few hammers and drifts, and he is set up. Small colliery proprietors, and sometimes iron-works-people, instead of sending for help to a boiler-making firm of standing, too often call in these small masters. When an accident happens, the evidence of empirics of this class is too often gravely taken as the evidence of "practical" men. Invariably the proprietor of the boiler is able to say that he has given orders for everything to be done to the boiler maker considered necessary. The boiler mender, knowing that, because of its lesser first cost, a patch would be far more in consonance with the proprietor's views than a whole plate, had patched, and not effectually repaired, the boiler; and he is always ready to declare to a coroner and jury that, in his opinion, all had been done that was necessary. Yet how frequently it turns out that the accident has happened almost immediately after the repairs have been done. In the case of a cylinder boiler at Dudley, not long since, this frequent patching over the fire had brought the longitudinal seams for several plates without break of joint. A patch had been

put on a few days before the explosion, and as the rivet holes had badly fitted, there had been much strain caused by drifting, and the rivets were much distorted. The frequent and badly executed repairs over the fire-place had so weakened the structure as to make it unable to bear the very high ordinary pressure. In the case at Great Bridge, which has called forth this article, the boiler maker had only at 4 o'clock finished putting in some 16 rivets over the fire to stop a leakage, and at 7½, half an hour after steam had been got up in it, the explosion occurred, killing three people. In this case the boiler maker acted up to the light which he promised, and the proprietors of the boiler had no reason to believe that it was not as much light as was needed. His evidence is, that when called in he found the boiler in good repair, with the exception of a few rivets over the fire, which were leaking. How should it be otherwise than in good repair, for during the past two years he had frequently mended it over the part where the fire was placed? He had never any idea that the boiler was rendered unsafe in consequence of these frequent repairs; and their instructions always were to do all repairs required. This man had no notion that the patching, in the manner in which it had been performed in this case, was the chief immediate cause of mischief. Mr. Marten, however, testifies—as every other competent engineer would have testified under similar circumstances—that "the rivets, which were put into the boiler in the very line of the seam where they gave way, had proved the great point of weakness. Immediately that the fire was put under, and the steam got up, the openings extended from rivet hole to rivet hole, and the boiler exploded."

A very practical view suggested itself to one of the jurors. If the putting of patch upon patch had reduced the strength of the boiler till it had become completely untrustworthy, although it might not leak, "some one ought to know whether it was worn out." Mr. Marten responded that "the experience of engineers, who saw so many cases of this kind, was that, though boilers in such a condition as the one in question might last for many years, sometimes they burst at once after being repaired. The question was, whether those who saw a boiler thought it was safe or not." One of the manager of the works, it transpired, who had been there 8 years, had never had any reason to believe it was unsafe; the boiler maker believed it safe; and the engine-tender, who had charge of the 6 boilers at the works, believed the same—indeed, did not see that it leaked until his son pointed out that defect. At the testimony of these workpeople no reader of "The Engineer" will be surprised. But the evidence of the secretary of the company was that all the boilers used by the company were insured with the Manchester Boiler Insurance and Steam Power Company, whose agents were accustomed to visit the works once in 6 months. On the 6th of October an external examination was made on behalf of the Manchester Company. "From that inspection he was led to believe that the boilers were in good condition." In May last the agent of the Boiler Company made an internal inspection, and suggested certain repairs, which it was not disputed were carried out. The secretary added, in reply to the coroner, that in May nothing was said as to the boiler being unfit for use, "or they should have condemned it." Yet, to replace this very exploded boiler, and also "any other which most required to be replaced," orders had been given for two new boilers. One of these Mr. Marten speaks of above. Even a Black Country juryman, when this last fact came out, wanted to know why, if the boiler was safe, it was to be replaced? The reply he obtained was, that "boilers, when they got to a certain point, might be considered safe, and yet want replacing."

The moral of all this must be tolerably patent to the reader. (1) When boilers need repairs, those repairs should be put into the hands of boiler-making firms who have a reputation to sustain. (2) The surest way to ascertain the true condition of a boiler is to examine it at frequent intervals in every part, both inside and outside. (3) When, as in this case, such intimation has been conveyed to proprietors — whether by boiler insurance agents or others — that the time has come when a boiler should be replaced, it is the truest economy to lay it off at once. (4) It cannot be too strongly urged upon users of steam power that it is far safer and cheaper to renew a boiler than to resort to continual, expensive, and unsatisfactory patching.

RAILWAYS IN RUSSIA.

From "The Engineer."

The following is a translation of an article on the construction of railways in Russia, from the "Russian Railway Gazette:"

Railway construction is a business which may be said to be novel, not only in our own country, but in Western Europe, where it originated. This particular kind of communication, entirely differing from all methods of locomotion that had hitherto preceded it, owing to the ardor with which it was prosecuted at the first onset, we admit must necessarily have been liable to all kinds of errors and perplexities at the beginning, owing, more particularly, to the circumscribed nature of the human intellect in not being able to conceive at once an object in all its bearings. Having found out the means of conveying passengers and guards expeditiously, punctually, and cheaply, from one point to another, all promoters of railway schemes seem to have considered their duties and obligations finally accomplished, and in laying down rails between the towns, have left the rest to the personal means and the desire of private individuals, in no way caring, not only for the convenience of passengers and senders of goods, but even for that which forms their most essential requirements. Instances of this kind can easily be adduced; it will be sufficient to point out this alone, and in the northern countries the warming of the railway carriages has not been introduced, and ventilation neglected, so that passengers particularly on long distances, are subject to all the evils connected with severe winters and vitiated atmospheres. But all these are still minor defects, offered by our railroads, in comparison with those which we shall endeavor to point out in the present article. We will not allude to sleeping cars, which are looked upon by many as an unpardonable luxury and indulgence.* Railways having effected a more accelerated and cheaper communication between the towns, have naturally conferred a greater boon upon the public; but, at the same time, the promoters, carried away, as it would seem, by the supposed magnitude of these benefits, have studied only too superficially, other circumstances, which they have deemed details beneath their notice. Having deprived the public of their former mode of travelling on common roads, the constructors of railways should have well studied the nature of all the salient points connected with this substitute for the former mode of locomotion, which latter, certainly, notwithstanding its slowness and dearness, had its good points. These good points consisted in this, that the driver of a vehicle conveyed the passenger from the place of starting to the place of destination; the same was done by the carrier of goods; whereas, with our railways, all this takes place very often between the towns, and the passengers and goods are landed in the open country, miles and miles away from their destination. Secondly, in this, that the passengers enjoyed, comparatively, a greater amount of comfort by the old method of travelling. Sledges were far more convenient than those narrow seats allotted by the constructors to the public, particularly in the third-class carriages.† It is difficult to understand why the constructors of railways have neglected these important and essential conditions connected with the very nature of the undertaking. In support of our assertion, that the constructors of railways, in laying down rails between the towns, have by far not fulfilled all their duties and obligations, may be taken some of the railway companies of Western Europe, who, after a lapse of between thirty and forty years of the railway era, are only now beginning to amend the errors originally committed, by introducing that which had been formerly neglected. At the same time it may be mentioned that sleeping cars are becoming more and more general on American lines.

The construction of railways in Russia was commenced much later than in Western Europe, and it might, therefore, naturally have been expected that the various errors originally committed there, in connection with such undertakings, would have been obviated in our country. Our

* Some sleeping cars attached to the first-class carriages of the Nicolai Railway, have been constructed by the railway contractors, Messrs. Wynam Brothers, at Alexandroffsky, near St. Petersburg, on the American principle.

† A great portion of what we term the respectable classes, travel third class in Russia, particularly on the Nicolai (St. Petersburg and Moscow) line.

promoters, constructors, engineers, and contractors, with few exceptions, have all been abroad, and have had opportunities of witnessing and experiencing for themselves all the imperfections still attending the present systems. One might, consequently, reasonably have hoped, that with the introduction of railways into Russia, the dictates of experience would have been followed without repeating the faults committed by others; but, unfortunately, just the reverse has happened. Our railways are being constructed without any regard to an independent consideration, not only of local conditions, but in many instances of general requirement; and in this regard our constructors up till now have appeared only in the light of imitators of very bad precedents. We have ventured thus strongly to express our opinion, for the reason, that we perceive, tuat whatever there is useful and commendable abroad in connection with railway construction, is with difficulty adopted in this country, and that the most flagrant errors are in many cases multiplied, if not in cubic, then at any rate in square proportion. Those who have travelled on our lines may have very likely often remarked, that in most instances the stations are situated far away from the town, and, as a matter of course, were breaking their heads to find out the reasons of such a peculiar arrangement; the cause is, nevertheless, very simple, and is to be attributed to the predominance of the private interest of the constructors. Usually, when the construction of a railway is mooted near any particular town, the value of town property speedily rises. On that occasion commences immediately a struggle between the constructors and the town proprietors. The former demand sacrifices in their favor; the latter, finding this the only opportunity for an advantageous sale of their property, naturally hold out for high prices. Should they, thereupon, fail to come to terms, the constructors will then, often out of spite, as well as for private interests, carry the station as far as possible from the town, thereby depriving the latter of most important advantages. As a case in point may be cited an instance where, in consequence of differences of this kind, near one town had to be constructed an extra intermediate station—the chief station, with its refreshment departments, being situated eight miles off, in an open field.

Facts of this kind speak for themselves, and it is only to be wondered at that such proceedings should be tolerated in a country which has any pretensions to civilization. The Government, in granting concessions, could easily put a check upon this license practised by the constructors, and not allow the interests of whole districts and thousands of inhabitants to be for ever sacrificed to the momentary advantages gained by the constructors. The principal cause of abuses of this kind consists in this: that the persons obtaining the concession, and afterwards the construction, and finally the management of the railways, seldom form one and the same united body, and, therefore, easily escape from any responsibility for the injury occasioned to a district. The construction of a line of railway in Russia is usually proceeded with in the following manner: One or more persons, frequently individuals without any substantial means of their own, but who, solely in virtue of interest and their connections, secure the concession, and that at the highest possible figure—as with us in Russia, for instance, 75,000 Rs. per verst (£13,000 per English mile), order abroad all the requisite machinery, materials, and conclude all the necessary contracts with the different works at home; the verst of line costing them some 60,000 Rs., if not less, and, thereupon, having shared among themselves 15,000 or 20,000 Rs. per verst, netted in this manner, consider their business definitely terminated. On the formation of the management, and the handing over to it of the contracts, these constructors disappear altogether, interesting themselves very little in the future fortunes of the line. The contractors fulfil their engagements according to agreements, and the management accepts matters just as they stand, without, of course, having the power of, in any way, altering already accomplished facts. From this state of things it appears clearly evident that, for the constructors, it is an easy matter to erect a station at a distance, say, of five versts from a town, should the inhabitants have in any way incurred their displeasure, as it is not the former who expect to avail themselves of the railway. For all this will suffer the inhabitants of

the town, the merchants forwarding their goods, and the shareholders—all those most innocent of the cause of this abnormal state of things. Here lies the root of those causes by reason of which railways are so far from fulfilling their purpose and obligations. Were the constructors not merely speculators, were they connected with the lines by stronger bonds, they would then not have neglected a single detail in order to enable the railways to return the greatest possible profits and to secure for the public the greatest amount of convenience. In that case stations would not appear miles away from the towns, the railway companies would then themselves take charge of goods at the same place of their storage, delivering them at their destination; then would disappear those legions of agents, or commissionaries, with which both the passenger and goods traffic is beset at present; and the former, acting by means of an improved mode of transit, would then be enabled fully to replace the former carriers.

THE LOUISVILLE BRIDGE.

From "The Iron Age."

Work on the great railroad bridge over the Ohio, at Louisville, is so far advanced that the engineers are confident of being able to open it for the passage of regular trains by the 15th inst. Construction trains, however, will be able to pass several days sooner.

The total length of the iron superstructure is 5,280 ft., of which two spans are respectively 370 and 400 ft. long. The middle and Indiana channels are "over grade" or "through;" the others, varying in length from 50 to 250 ft., are "under grade" or deck. The under grade portion is of the same plan known as Fink's Patent Suspension Truss—a plan that has been well and favorably known for over 20 years.

The 400 ft. span now rests on its permanent bearings, and is in every respect satisfactory to its engineers. This, by the way, is the longest span ever erected in America, the next less being the main span of the Victoria Bridge, at Montreal, Canada, which is 330 ft. long, and the channel span of the Steubenville Bridge, which is 320 ft. long. The plan of truss is that known as the "triangular," one which has been extensively and successfully used by Mr. Fink, and has been in the present case especially arranged for this long span. The clear space above low-water line under this span is 96½ ft., and above high-water line 45½ ft.; the total height from the rock bed of the river to the top of the upper chord of this span is 160 ft.

The total quantity of iron, wrought and cast, used in the construction of this great bridge, is 8,700,000 lbs., and the amount of timber including rails, joists, cross-ties and railway, will be 640,000 ft., board measure.

Considering the large number of men employed on the structure, and the character of the work, few accidents have occurred. In almost every case in which men have been killed or injured, it has resulted from their own carelessness. The company have taken particular pains to provide means of rescue for those who may fall into the river, and several skiffs, with two men in each, are always moored below, ready to give aid in case of emergency. Very few visitors are allowd on the bridge, for fear of accidents to them, where so many men are at work. One can get a pretty good idea of its immensity, however, from the city wharf, where numbers go every day to see it.

A curious work is going on near Ceylon, in the deepening of the sea channels between that island and India, by cutting away the connecting reef, so as to allow shipping of larger tonnage to pass. This has been in progress for 10 years, with a considerable increase of depth and of the number of ships. The work is executed by convict labor.

It is said that a Russian line of steamers from the Black Sea to Bombay, *via* the Suez Canal, is about to be established, with contracts already made by one house at Moscow to ship 4,000 bales of cotton per week.

THE HEATON STEEL PROCESS.

MONSIEUR GRUNER'S REPORT.

(Continued from page 97.)

V.—TENSION TESTS OF THE STEEL.

I have quoted in the preceding paragraphs some of the results obtained by Mr. Kirkaldy from his tension tests of the Moselle steel. I have united them in this Table with a view to readier comparison. I add the breaking strain calculated upon the area of fracture as well as the percentage of carbon which I found by the Eggertz method in the tested bars.

Description and Numbers of the bars.	Dimensions of the bars in inches.	Area of original section in square inches.	Breaking Load. Tons per square inch. (Original area).	Breaking Load. Kilos. by millimetre-carre. (Original area).	Breaking load in kilos. by sq. mm. of area of fracture.	Proportion of the area of fracture to original area.	Elongation per cent. on the original length.	Percentage of carbon in the tilted bars.	Notes.
No. 14. Cast steel (Longwy), second conversion. Mean of six tilted bars.........	½	0.267	49.5	77.90	109.7	0.71	12.5	0.0093	The fractures of all the bars present nearly the same appearance. It is granular, less fine, but more crystalline and more brilliant than the best steel. A characteristic of the fracture which seems to us peculiar to this metal is the appearance of two dark, dull bands along the diagonals of the square of the section.
No. 15. Cast steel (Longwy), third conversion. Mean of six tilted bars.........	½	0.267	52.0	81.9	87.1	0.94	4.0	0.0055	
No. 16. Cast steel (Longwy), fourth conversion. Mean of six tilted bars.........	½	0.266	49.1	77.3	84.9	0.91	6.0	0.0035	
No. 17. Cast steel (Hayanges), fifth conversion. Mean of four tilted bars........	½	0.279	50.9	80.1	84.3	0.95	3.1	0.0037.	
No. 18. Cast steel (Hayanges), sixth conversion. Mean of four tilted bars........	¾	0.562	37.8	59.5	61.1	0.97	1.3	0.0032	
No. 19. Cast steel (Hayanges), eighth conversion. Mean of four tilted bars..	½	0.275	50.3	79.2	83.9	0.94	3.2	0.0048	

To appreciate the real significance of the figures in this Table we must compare them with the results obtained from the steels of established reputation. Table F of Mr. Kirkaldy's work gives us the following results:

Description of the steels (½ in. to ¾ in. bars).	Breaking load in kilos. per square millimetre of the original area. Mean of many tests.	Breaking load in tons per square inch of original area.	Breaking load in kilos. per square millimetre of the area of fracture. Mean of many.	Breaking load in tons per square inch of area of fracture. (Mean).	Elongation per cent. of original length.	Character of fracture.
Turton tool steel.......................	93	59	98	62	5.4	Fine Grain.
Jowitt chisel steel.......................	88	55	105	67	7 1	"
Krupp cast steel, rolled for............	60 to 67	41	97	62	15.3	Partly fibrous and silky lustre.
Shortbridge homogeneous iron, hammered.............................	59 to 66	39	85	54	11.9	"
Jowitt spring steel, tilted..............	45 to 48	32	67	42	18.0	"
Mersey Company puddled steel, tilted..	47 to 53	32	77	49	19.1	Fibrous.

The percentages of carbon are not given, but we know by the use for which these steels are destined that the two first are hard steels, with a percentage of 0.006 to 0.010; the four last soft steels, or homogeneous iron, containing little more than

0.003 to 0.005 of carbon. By this we see that the Longwy steels produced from pigs containing but little silicon would be soft steels of fair tenacity but small elongation, especially so as to samples Nos. 15 and 16, obtained with a small charge of nitrate. The Hayanges steels show less tenacity and insufficient elongation. They are "short," though they contain a very small percentage of carbon, a defect which results from the presence of phosphorus not removed by the nitrate. Let us also compare the Moselle steels with the Swedish and Austrian steel. According to Mr. Kirkaldy's tests, the following are the results obtained by the Fagersta Bessemer steels:

Breaking Load.		Breaking Load.		Comparison of the area of fracture with the original area.	Elongation per cent. on the original length.	Percentage of carbon.
In tons per square inch.	In kilos. per sq. millim.	In tons per square inch.	In kilos. per sq. millim.			
Of original fracture.		Of area of fracture.				
59 to 69	93 to 109	57 to 64	89 to 103	0.91 to 0.95	2 to 6 per 100	0.0100
54 to 65	86 to 102	45 to 58	71 to 92	0.80 to 0.82	4 to 6 "	0.0070
58 to 65	90 to 103	45 to 46	70 to 73	0.68 to 0.82	9 to 10 "	0.0045
85 to	133 to 134	31 to	48 to 49	0.36 to 0.37	to 12 "	0.0035
53 to 58	106 to 119	26 to 26	42 to 44	0.37 to 0.46	11 to 22 "	0.0030

The Neuberg steels that have been tested at Vienna have yielded the results which are indicated in the following Table:

Breaking Load.		Elongation per cent. of the original length.	Percentage of carbon.	Observations.
In tons per sq. inch.	Kilos. per sq. mm.			
Original area.				
57 to 65	89 to 105	5 per 100	0.0088 to 0112	Brittle when too highly tempered.
46 to 57	73 to 89	5 to 10	0.0062 to 0088	Tempers well.
36 to 46	56.5 to 73	10 to 20	0.0038 to 0062	Ditto.
31 to 36	48 to 56.5	20 to 25	0.0015 to 0038	Hardens very little.
35 to 31	40 to 48	25 to 30	0.0005 to 0015	Does not harden at all.

In comparing these Tables we at once see the perfect agreement of the results obtained in the two countries. On the one hand, the elongation increases in proportion to the diminution of carbon in the steel; and, on the other hand, the breaking loads, as compared with the original area, decrease with the percentage of carbon, but, as compared with the area of fracture, vary very little. If, now, we compare these figures with those which we obtain in the case of the Moselle steels, we shall see that the elongation of the Swedish and Austrian steels, with 0.0045 to 0.0060 of carbon, is from 9 to 10 per 100; while in the case of the Moselle steels (Nos. 15 and 19) it only runs from 3 to 4 per 100. The breaking load, compared with the original area, is 51 to 52 tons in the case of these two Moselle samples, while in the case of the Swedish and Neuberg steels the maximum is 46 tons per sq. in. The strength is increased by the silicon and phosphorus; but the inferiority of the Moselle steel appears again when we compare the breaking loads calculated per sq. in. of the area of fracture. In the Swedish steel the breaking loads exceed 57 tons, and often 64 tons, while the No. 15 Longwy sample only reaches 54 tons (87 kilos.), and the Hayanges (No. 19) only 84 kilos.

Finally, when we compare the steels containing a low percentage of carbon—viz.,

from 0.0032 to 0.0037—we see that the elongation of the Swedish and Austrian samples reaches 12 and even 20 per cent. The Hayanges steel only reaches 3 per 100. The Longwy steels, more highly purified, are more ductile. The No. 14, produced with the maximum charge of nitrate, elongated 12.5 per cent. As to the breaking loads, calculated with reference to the original area, the Moselle samples generally give the best results, viz., 37 to 50 tons, instead of 30 to 36 tons; but calculated upon the area of fracture, the No. 14 only can compare with the Swedish steels. That gives 70 tons (109.7 kilos.), as against 105 to 134 kilos., while the steels Nos. 16 and 17, being less pure, only go to 84 and 85 kilos., and No. 18 only to 61 kilos. (38 tons). In a word, we may conclude from the foregoing analysis that the Heaton process does not readily produce hard steel of good body from phosphoric pigs, but that it will produce soft steel and homogeneous iron, which differ only from the common Bessemer steels by a somewhat greater stiffness and by a diminished tendency to elongation under heavy loads. It remains for us to show to what extent this defect is due to phosphorus, and to what extent it is possible to purify the metal by the Heaton process.

I will only remark, before I have done with the question of the quality of the steels, that, to be quite sure of the conclusion, we shall have to investigate their dynamic resistance as in the case of malleable iron. We shall only arrive at the relative value of the different steels by determining accurately the effect produced on the bars by loads which do not strain them beyond the limits of their elasticity.

VI.—CHEMICAL EXAMINATION OF THE PRODUCTS OF THE NITRATE REFINING PROCESS.

I have already given the analysis of the Moselle pigs. Now for the analysis of the crude nitrate used at Langley Mill. It was of consequence to determine the percentage of sulphur and phosphorus in the reagent used. The salt is yellow, in crystalline lumps. It was kept in a damp cellar at the works. Nitrate of soda, 90.89; chloride of sodium, 2.73 (containing chlorine 1.64); sulphate of lime, 0.22 (containing SO^3 0.12); sand, 0.28; water, 5.88; phosphoric acid, traces; total 100.00. Pure nitrate contains 36.61 per 100 of soda; consequently, the crude salt contains 33.27 per 100, or, if we add the soda in the chloride, 34.7 per 100.

The products of the Heaton refining process are crude steel and slags. The refined metal is itself converted partly into malleable iron and partly into steel. Let us examine each of these four products. Refined metal: The refined metal is a spongy mass, granular or crystalline, a kind of vesicular fine metal, the different parts of which are unequally purified. This lack of homogeneity is perceptible to the naked eye. The grain varies in size. I have a small sample of the second conversion, the large-grained portions of which, analyzed by the Eggertz method, give 0.0024 of carbon; the fine-grained, 0.0125, and a mixture of the two, 0.0045. The analyses I am about to give show also the somewhat unequal distribution of the silicon and phosphorus. At the moment when the converter bottom is upset on the floor of the works, we see that some portions of the solidified mass, being still fluid, disengage themselves and run off. These more fusible portions always contain more silicon and phosphorus than the solidified mass, and they are recognized in the laboratory by their greater resistance to nitric acid. To arrive at an accurate idea of the purification of the product it will not do to confine ourselves to an isolated examination of a sample of the refined metal. It is better to analyze the steel ingots produced by remelting in the crucible. There is another circumstance, too, which tends to falsify the results of this analysis. The vesicular metal always contains, intimately incrusted with it, or in the shape of a thin film in the interior of the bubbles (blisters), scoriacious matter (particles of slag), the existence of which is proved by analysis, but which cannot be thoroughly separated from the metal itself. And now let us give the results of some of the analyses of the refined metal, and see what deductions we may draw from them. But let me further remark that, in order to obtain results better admitting of comparison, I have preferred to analyze the cakes, that is, the refined metal rapidly reheated and shingled in the way I have described, rather than the spongy mass as it comes from the converter. This, I repeat, is always wanting in homogeneity, and more or less intermingled with slag. The cakes, it is true, are

not perfect in either respect, but they are certainly more uniform in texture. The cakes were analyzed, like the pigs, by dissolving five or ten grammes in nitric acid, evaporating to dryness, calcining the product to render the silica insoluble, taking up the oxides by hydrochloric acid, precipitating the iron in the state of sulphide, and determining the phosphorus in the condition of phosphate of magnesia. This phospate, be it said, was dissolved and reprecipitated to make sure of its purity; and the soluble silica, which is always to some extent taken up by the sulphide of iron and the phosphate of magnesia, was accurately determined. The sulphur was tested separately, either by the common method or by the Eggertz method; then the carbon was determined by the Eggertz method. I did not determine the other ingredients, unless perhaps the sodium in one of the samples; and, besides, I ascertained the presence of very decided traces of vanadium in the pigs. It is perceptible even in the steels, though the greater part of it passes into the slag in the form of vanadate of soda. We analyzed four cakes; they were the products of the first conversions of Longwy pig and the two first of Hayanges pig. The Longwy cakes were flattened cold under the hammer, and dissolved easily in nitric acid; the Hayanges cakes are harder and finer-grained; they will not hammer out cold, and will not dissolve in nitric acid unless heat be applied. There are indications of a less perfect purification, which, in fact, are confirmed by the analyses. Here are the figures:—

Ingredients tested.	Conversion No. 1.	Conversion No. 2.	Conversion No. 5.	Conversion No. 6.	Remarks.
Undissolved slag	0.0020	0.0006	0.0025	0.0078	All the silica figures here as silicon, though part of it must have been due to the slag intermixed with the metal.
Silicon	0.0016	0.0014	0.0053	0.0045	
Phosphorus................	0.0064	0.0059	0.0092	0.0078	
Sulphur	0.0019	....	0.0001	....	
Carbon......................	0.0120	0.0125	0.0121	0.0152	

We will begin by observing that the figures placed opposite the undissolved slag do not represent the whole amount of slag intermixed with the metal.

The slag is decomposed for the analysis by acids. These separate from it a basic portion which is dissolved, while the residue is an acid silicate which we isolate from the true silica by removing the latter in an aqueous solution of caustic potash. The quantity dissolved by the acids is in proportion to the basic character of the slag itself. Now, in this respect there is a great difference, as we shall presently see, between the slags resulting from conversions Nos. 1 and 2 and those of conversions Nos. 5 and 6. These last contain more than 50 per cent. of silica—the former about 30 per cent. These consequently leave a smaller residue, and as they contain 15 to 16 per cent. of phosphoric acid, while the slags of conversions Nos. 5 and 6 do not contain 2 per cent., it follows that an appreciable quantity of the phosphorus given in the analysis of the refined metal of Nos. 1 and 2 must come from the adherent slags. One per cent. of true slag mingled with the metal would suffice to contribute 0.0016 of phosphoric acid, or 0.0007 of phosphorus to the analysis of the cakes. Thence it follows that in the refined metal, the produce of conversions Nos. 1 and 2, the proportions of phosphorus should be really about 0.0055 or 0.0050, instead of 0.0064 or 0.0059.

This being the case, we see, on comparing these analyses with the analyses of the pigs, that the gray silicious pigs are far less purified than the white pigs—that the silicon oxidizes before the phosphorus, and that the carbon oxidizes last. But unfortunately we see that, even in the most favorable case, the dephosphorization is far from complete. The purified product still retains 0.005 of phosphorus when we deal with pigs which contain 0.014 to 0.015. However, this conclusion must not be taken as *absolute*. The purification depends on the percentage of nitrate used; besides, we must remember that, the refined metal not being homogeneous, we must consult the analysis of the steel ingots to ascertain the true de-

phosphorization. We find a proof of the lack of homogeneity in the fact that the metal No. 1 retains more phosphorus than No. 2, while the reverse ought to be the case according to the charges of nitrate used in the conversions. In any event, if we refer to the observations made at Konigshutte on the refining of phosphoric pigs by the Bessemer process, we must not be astonished if cast-steel with as much as 0.005 of phosphorus should work almost as well when hot as pure steel. Dr. Miller, of King's College, found 0.0014 of sodium in the refined metal—in fact, I believe it always contains some. The soda, in percolating the molten metal, is, like the nitric acid, partially deoxidized by the carbon and the iron, but it is impossible to determine the sodium accurately on account of the presence of slag in the iron. I did indeed try—by treating the crude steel with hot water—to dissolve the soda belonging to the slag, but the slag only yields a portion of its alkali to the water, so that when we subsequently endeavor to determine the sodium in the washed metal, we cannot tell whether or not it comes from the crude steel or the associated slag. However that may be, the refined metal of the third conversion gave me 0.0006 of sodium, after having been, as far as possible, deprived of the adherent slag—by washing in boiling water—at the risk, it is true, of also dissolving a portion of the true sodium. In any event, the alkaline metal ought to be rather beneficial to the final product. In the final melting for cast-steel it ought to act again upon the phosphorus and sulphur.

Slags.—The second product of the Heaton process is the akaline scoria resulting from the action of the nitrate of soda. I restricted myself to a complete analysis of two samples—the slag of the first and fifth conversions. But I satisfied myself that the slags of the first four conversions are nearly identical, as also those of the four last conversions. We have already seen that they are of two very distinct types—due to the different proportions of silicon in the pigs. These are the results:

Elements determined.	Slag of the first conversion. Longwy white pig.	Slag of the fifth conversion. Hayanges gray pig	Slag of the eighth conversion, partially analyzed.
Silica	0.310	0.540	0.545
Phosphoric acid	0.158	0.016	0.018
Sulphuric acid	0.007 }	0.005	.....
Sulphur	0.006 }		.....
Chlorine	0.007	0.002	.....
Soda	0.304	0.290	0.305
Lime	0.010	0.008	0.005
Magnesia	traces	0.004	.....
Protoxide of iron	0.144	0.080	0.080
Protoxide of manganese	0.046	0.041	0.034
Oxide of vanadium	0.005	0.006	.....
Sulphur, chlorine, vanadium, magnesium, etc., by difference	.....	.....	.013
	0.997	0.992	1000

The slags resulting from the two varieties of pig contain the same elements and nearly the same proportion of soda, but the opaque dull slags of the Longwy white pig are rich in phosphoric acid, while the vitreous slags of the Hayanges gray pigs are silicious, so that the character of the slags tends to support the conclusions already arrived at as to the more imperfect purification of the silicious pigs. The proportion of oxide of iron is also less in the silicious slags of the Hayanges pig than in those of the Longwy pig ; but in both cases the percentage of iron is small, and the waste altogether minimum. In the conversions of the Longwy pig the weight of the slag is, in fact, as we shall see, about 60 kilos. (132 lbs.), that is to say, less than 9 per cent. of the weight of the pig metal refined. Now the 0.144 of protoxide of iron corresponds to 0.112 of metallic iron, of which

the 9 per cent. make 0.0101; which proves that the nitrate has not oxidized more than 1 per cent. of the pig treated. On the other hand, in treating the Hayanges pigs the maximum weight of the slags is 85 kilos. (187 lbs.), say 12 per cent. of the weight of the pig, and, as the scoria contains only 0.08 of protoxide of iron, or 0.062 of metallic iron, the pig has only parted with 0.062 of the 12 per cent. to the slag—say, 0.0086 of metallic iron—that is, less than 1 per cent. We see, then, that in this process the waste of iron is almost *nil*, and that the waste is solely due to the oxidizing of foreign matters. This confirms the figures of 6 per cent. above given, as the mean of the results obtained from the Hayanges pig conversions.

The slags contain metallic shot or globules; these were carefully separated by means of a magnet before analysis. The slag of the first conversion yielded 8.3 per cent. of shot, those of the fifth and eighth conversions between 5 and 6 per cent.; but these figures are variable, depending on the choice of samples; and in general, as we shall see, the percentage of shot is higher. The pigs of Longwy and Hayanges, as we have already said, yield very different slags. Water and acids do not dissolve them in the same way.

Water easily decomposes the slag of the Longwy pig. The result is a green solution, which turns yellow after parting with a slight black deposit. The liquor contains a sulphide of sodium, which blackens silver, and it is this compound which first of all retains a little sulphide of iron and keeps in solution the sulphide of vanadium. Water, however, only removes a portion of the soda. It transforms the silico-phosphate into a basic compound soluble in water, chiefly formed of phosphate of soda, and into an insoluble residue retaining the greater part of the silica, about one-third of the phosphoric acid, and all the non-alkaline bases. The vanadium also is partly retained by the insoluble silicate.

When we moisten the slag and leave it exposed to the air, it partially decomposes. The silicate of soda is transformed to carbonate. In treating the slag of the first conversion with water, 0.386 of it is dissolved, and we find in the solution 8 to 9 per cent. of silica, 25 per cent. of phosphoric acid, and 62 per cent. of soda, while the insoluble residue is composed of 50 per cent. of silica, 9 to 10 per cent. of phosphoric acid, 10 to 11 per cent of soda, and about 30 per cent. of oxides of iron, manganese, etc. If we compare these figures with those of the analyses, we see that water removes about five-sixths of the soda, one-tenth of the silica, and two-thirds of the phosphoric acid.

Hydrochloric acid completely dissolves the Longwy slag. Sulphuretted hydrogen is liberated. On evaporating to dryness and redissolving in acid there is generally a residue of pure silica, but if it is overheated, and the acid employed is not very concentrated, it may also happen that the silica will retain various phosphates which the acids will not take up. The vanadium is chiefly concentrated in the alkaline solution, but is also partially taken up by the phospate of magnesia. The blue tint of the salts and the red coloring of the ammoniacal sulphate of vanadium leave no doubt upon this point. I have besides proved the absence of chrome, and verified the formation of vanadic acid by treatment with nitre.

Water also dissolves the Hayanges slags. When hot the liquor is colored brown (viz., sulpho-vanadate of soda), but the solution is chiefly composed of silicate of soda with an excess of base. The slag No. 5 yields 0.39 of its weight to water; the slag of No. 8, 0.34. In both cases the insoluble residue softens at a low red heat. The aqueous solution contains two-thirds of the soda, half the phosphoric acid, and nearly one-third of the silicic acid. Neither hydrochloric acid nor sulphuric acid entirely dissolves the Hayanges slag. It is too silicious for that. The residue is a silico-phosphate with an excess of acid, forming from 0.25 to 0.30 of the original slag. To determine the silica we treated the substance with a mixture of carbonate of soda and nitre; we so obtained silica tinted somewhat yellow by the vanadic acid. To determine the soda we used hydrochloric and sulphuric acid.

In all the slags, but especially in that of the Hayanges pigs, the sulphur is a little oxidized. It is generally found in them combined with sodium, so that, in spite of the presence of nitric acid, the soda equally gives up a part of its oxygen to the oxidizable elements of the pig.

Now let us try, by the aid of these an-

alyses which I have given, to determine the degree of refinement at which it is possible to arrive by the Heaton process. To this end, let us first calculate the quality of oxygen which the nitrate can supply. Assume that the nitric acid be simply reduced to the condition of dentoxide of nitrogen, but that the water in the nitrate be entirely decomposed, 100 kils. (220 lbs.) of Peruvian nitrate would liberate—for the 90.89 kilos. of pure nitrate, 25.5 kilos. of oxygen, equal to 55½ lbs.; and for the 5.88 kilos. of water, 5.2 kilos. of oxygen, equal to 11.4 lbs. If, on the contrary, the nitric acid were completely decomposed, we should have—for the 90.89 kilos. of nitrate, 42.5 kilos. of oxygen, equal to 93.4 lbs.; and for the 5.88 kilos. of water, 5.2 of oxygen, equal to 11.44 lbs. Total 47.7 kilos., equal to 196 lbs. Let us compare with these figures the quantity of oxygen which would be requisite for the complete oxidization of all the foreign elements in the Moselle pig. We will take first of all the Longwy pig of the first conversion. The weight converted was 720 kilos., equal to 15.84 lbs., irrespective of the two iron bars. Assuming, according to the foregoing analysis, 0.9 per cent. of silicon, 1.42 per cent. of phosphorus, ⅓ per cent. of sulphur, and 3 per cent. of carbon, of which about the half had to be expelled, there would be required to oxidize these elements:

		kilos.		lbs.		kilos.		lbs.	
For the 0.9	p. c. say	6.48	=	14	silicon	7.02	=	15.444	oxygen.
" 1.42	"	10.22	=	22.48	phosphorus	13.01	=	28.6	"
" ⅓	"	2.40	=	5.28	sulphur	2.40	=	5.28	"
" 1.5	"	10.80	=	23.76	carbon transformed into carbonic oxide.	14.40	=	31.68	"
					Total	36.83	=	81.004	

Now, for the first conversion there were used 68 kilos. (149 lbs.) of nitrate, which would yield on the first hypothesis, 20.88 kilos (45.9 lbs.) of oxygen, and on the second 32.44 kilos. (71.3 lbs.) of oxygen. We see, then, that on the most favorable theory the proportion of oxygen yielded by the nitrate was insufficient to oxidize all the impurities. A *fortiori*, it must have been so in practice, since, putting aside the iron, we have to take into account the oxygen taken up by the manganese, the vanadium, the earthy metals, etc., contained in the pigs; and, on the other hand, the nitrous gas, which we see evolved during the conversion, proves that at least a portion of the nitric acid is simply reduced to the state of dentoxide of nitrogen. It is not, therefore, to be wondered at that the refined metal should still retain some phosphorus and silicon, and that a very small quantity of iron should have been oxidized. One can understand, too, that the soda itself may be partially reduced under these circumstances.

Let us calculate by the analysis of the cakes of the first conversion how much oxygen would be requisite to complete the refining of the converted metal. The weight of this product, reckoning the splashes of metal, was, in this conversion, 1470 lbs. (669 kilos.); or, rather, if we add the weight of metallic shot found in the slag, 671 kilos. (1476 lbs.), this will give us:

	kilos.		lbs.	kilos.		lbs.	
For the 0.0016 of silicon, say	1.07	=	2.354	1.16	=	2.552	oxygen.
" 0.0064 of phosphorus, say	4.29	=	9.438	5.46	=	12.012	"
" 0.0009 of sulphur, say	0.60	=	1.320	0.60	=	1.320	"
Total			13.112	7.22		15.884	

Now this is a minimum, since the cakes, owing to the oxidizing reheating, are purer than the spongy metal as it comes out of the converter. Deducting the 15.8 lbs. from the 81 lbs., we see that to arrive at the result obtained, the nitrate should have furnished 65 lbs. of oxygen, say 44 per cent. Consequently, the greater part of the nitric acid must have been converted to nitrogen, or to protoxide of nitrogen. We see, too, that to obtain the indispensable proportions of oxygen, the charge of nitrate should have been increased by at least 15 kilos. (33 lbs.) But even then, the purification would not have been complete, since some portion of the oxygen in question would have reacted on the iron and the. carbon. If, then, the

bar iron, prepared from the refined metal of the first conversion, shows the characteristics of burnt iron, we must attribute it to the reheatings, and not to an excess of nitrate in the converter. The analyses, in fact, as well as the remeltings for steel, prove that the cakes resulting from the first conversion were sufficiently carburized. But, had they not been so, I should not, on this account, fear an excess of nitrate. It would be always easy to restore the proper percentage of carbon to the refined metal. It would suffice to add at the remelting for steel a sufficiently large percentage of pure spiegeleisen, as is done in the Bessemer and Martin processes.

There would, however, be two objections to the use of an excess of nitrate. In spite of the extra heat which would be evolved, we might fear that the metal would not remain fluid to the last, and that it might in consequence lose its homogeneity; and then there would be the extra cost; instead of 68 kilos. (150 lbs.) of nitrate, 83 or 85 kilos. (182 lbs. or 187 lbs.) would be required, say 11½ or 12 per cent. instead of 9½ per cent.

The refined product is not homogeneous, and would no doubt be even less so if the decarburization were more advanced. But this seems to me to be a matter of small consequence, since, in any event, the refined product has to be remelted in the reverberatory furnace. It is perfectly evident that the most economical method would be to run the refined metal straight from the converter into the reverberatory furnace, which appears to me to be easy to manage. As to the cost of these heavy charges of nitrate, we cannot pretend to ignore the fact that it will be large, especially at the present price of nitrate. But on this head I propose presently to suggest a modification of the process which would allow of the charge of nitrate being very considerably reduced.

Let us go into the same calculations with regard to the Hayanges gray pig. According to the analyses I have given, the remelted Hayanges pig contains 3 per cent. of silicon, 1.27 per cent. of phosphorus, 0.1 per cent. of sulphur, and 3 per cent. of carbon. If we propose, as above, to remove only half the carbon, we should require to oxidize these elements in a charge of 705.7 kilos. (13 cwt. 95 lbs.) of pig, which was the weight of the three last conversions—the following quantities of oxygen—for 3 per cent., or 45 lbs. of silicon, 50 lbs. of oxygen; for 1.275 per cent., 20 lbs. of phosphorus, 25 lbs. of oxygen; for 0.10 per cent. or 1.6 lbs. of sulphur, 1¼ lbs. of oxygen; for 1.50 per cent. or 23 lbs. of carbon, 31 lbs. of oxygen; total, 108 lbs. of oxygen. Assuming that the nitric acid gave up all its oxygen, these 108 lbs. would have required 226.6 lbs. of nitrate; now the maximum used was 199 lbs. The purification, then, could not be complete, and all the less so that the nitric acid is not entirely decomposed, and that the iron, the manganese, and the other elements absorbed at least 11 lbs. of oxygen, or 24 lbs. of nitrate, according to the proportion of metallic oxides in the slags. *A fortiori*, then, we need not be astonished if the metal produced by the fifth and sixth conversions still contains a notable percentage of phosphorus and silicon, since only 147 lbs. of nitrate were used in the fifth, and but 169 lbs. in the sixth conversion.

Let us calculate how much oxygen would have been required to finish the refining in the fifth conversion.

The refined metal weighed 647 kilos. (1,423 lbs.); or if we add the 5.2 per 100 of shot in the 114 kilos. (250 lbs.) of slags, 653 kilos. (1,436 lbs.). Now, taking the analysis of the cakes which we have given above, the 653 kilos. (1,436 lbs.) contain 0.0053, or 3.46 kilos., equal to 7 lbs. of silicon, which would have required 3.75 lbs. equal to 8.250 lbs. oxygen; 0.0092, or 6.01 kilos., equal to 13 lbs. of phosphorus, which would have required 7.69 kilos., equal to 16.9 lbs. oxygen; 0.0001, or 0.06 kilos., equal to 0.13 lbs. of sulphur, which would have required 0.06 kilos., equal to 0.13 lbs. oxygen; total, 11.50 kilos., equal to 25.3 lbs. of oxygen.

And these 11.50 kilos. (25 lbs.) are a minimum, seeing that the crude steel, as it comes from the converter, is not so pure as the cakes; and when we consider, too, that the alkaline salt is not completely decomposed, we see that the charge of nitrate should have been augmented by at least 30 or 35 kilos. (66 lbs. or 77 lbs.), which would bring us nearly to the same figure we before arrived at—103 kilos. (226 lbs.)—and shows us that in any event, instead of 9.4 per cent. of nitrate, 14 or 15 per cent. should have been used. Hence it is evident that the refining of silicious brands by the Heaton process

would be too costly, and that we must, in any event restrict its use to white pigs, the price of which, however, as we all know, is less than that of gray pig.

Now let us ascertain from the analyses what becomes of the soda of the nitrate and the phosphorus of the pig in the converter. If we knew the exact weight of the slags, and if they were as homogeneous as the cakes, we could calculate from the analyses the quantities of phosphoric acid and soda carried off in the slag, and compare the result with the quantities in the pig and in the nitrate. We can do so approximately in the case of the Hayanges pigs; it is more difficult in the case of the Longwy pigs, the slags from which are scarcely homogeneous and but little fluid. A considerable quantity of them adhered to the lining of the converter, and could not be weighed.

We will first of all see what we can learn from the slags of conversion No. 5. They weigh 114 kilos. (250 lbs.); or, if we deduct the 5.2 of metallic shot, 108 kilos. (237 lbs.). But it is easy to see that this figure of 108 kilos. (237 lbs.) is too high, for the slag would contain more soda than the nitrate itself could have yielded. The same observation applies to the slag of the last three conversions. The mass weighed certainly contains more globules of metal than the sample chosen for analysis. We arrive at the same conclusion, too, by calculation. As the lining of the converter is hardly at all attacked by the nitrate, we can reckon approximatively the weight of the slag by the amount of silica that would be yielded by the pig and the sand.

We have already seen that the 706.8 kilos. (13.91 cwt.) of pig converted in the fifth operation contain 3 per cent. of silicon, say, 21.20 kilos. (46.6 lbs.); the cakes retain after conversion, 3.40 kilos. (7.9 lbs.); the difference, say, 17.74 kilos. (38.4 lbs.) represents the silicon given up to the slag. The corresponding weight of silica is 36.96 kilos. (81 lbs.); we must add the silica of the sand used as a diluent, 9.36 kilos. (20 lbs.), and the result is for the silica of the slag, 46.32 kilos. (101 lbs.).

And as by the analysis the slags contain 0.54 of silica, we find the weight of the slags to be

$$101 \times \frac{100}{.54} = 187 \text{ lbs.}$$

This weight is probably still in excess of the truth, because the silicon returned in the refined metal is probably rather greater than what is shown by analyses of the cakes. If, however, we admit these figures, we shall find that the analysis will give us for the quantity of soda, $0.29 \times 85 = 24.65$ kilos. $= 54$ lbs. On the other hand, as 100 parts of crude nitrate yield a maximum of 34.7 of soda, we see that the 67 kilos. (147 lbs.) of nitrate used in this conversion could only have yielded 23.25 kilos. (51 lbs.) of soda. These results do not exactly agree, and that goes to prove what I said—that the weight of the slag could hardly have been more than 80 kilos. (176 lbs.). We may, however, deduce this further conclusion, viz., that very little of the soda could have escaped the action of the silica, and that very little could have been volatilized, or passed in the shape of sodium into the refined metal.

Let us apply the same calculations to the phosphorus. The pig converted contains 9.01 kilos. (19.8 lbs.) of phosphorus; the cakes retain of it 6.01 kilos. (133 lbs.); the weight eliminated from pig is 3.00 kilos. (6.6 lbs.), which ought to have yielded 6.80 kilos. of phosphoric acid.

Now, reckoning the contents in phosphorus of the slag at 0.016, the 85 kilos. (187 lbs.) of slag only contain 1.360 kilos. (2.9 lbs.); that is to say, the one-fifth part of the phosphorus eliminated from the pig. The difference is so great that we must conclude that in the presence of excess of silica the greater part of the phosphorus must have been volatilized, either in the form of free phosphorus, phosphorous acid, or phosphoric acid.

We have not all the materials for working out these calculations for the sixth and eighth conversions. We can, however, ascertain that the weight of slag must have been between 80 and 100 kilos. —that almost the whole of the soda is contained in them, and that the greater part of the phosphorus eliminated has been volatilized.

If we now repeat these calculations for the Longwy slags, which contain little silica, we shall find the results will be very different. Let us examine the first conversion. The 720 kilos. (1,584 lbs.) of pig converted at 0.009 of silicon contain 6.48 kilos. (14 lbs.); the cakes at 0.0016 retain of it 1.07 (2 lbs.); there remains of

silicon passed into the slag, 5.41 kilos. (12 lbs.); which corresponds to silica, 11.27 kilos. (24.6 lbs.); we have to add for the .9 of silica from the diluent sand, 8.10 kilos. (18 lbs.); which will give as the total silica of the slags, 19.37 kilos. (42 lbs.). Consequently, as the slags contain 0.31 per cent. of silica, we have as their total weight

$$19.37 \times \frac{100}{31} = 62 \text{ kilos.} = 136 \text{ lbs.}$$

$$42 \times \frac{100}{31} = 136 \text{ lbs.}$$

This figure is much higher than the 25 kilos. (55 lbs.) found by experiments; but I have already observed that these basic slags are very pasty, and that a very considerable percentage of them adheres to the lining of the converter. On the other hand, the figure of 62 kilos. (136 lbs.) is perhaps rather too high, because, as I before said, the refined metal ought to retain more silicon than the cakes do. We must, then, consider these 62 kilos. (136 lbs.) as a maximum. Consequently, as the slags by analysis contain 0.304 of soda, we shall have also for the alkaline bases, on multiplying the 62 kilos. (136 lbs.) by 0.304, a maximum of 18.85 kilos., or 41 lbs.

Now, on the other hand, the 68 kilos. (150 lbs.) of nitrate ought to have yielded the still higher figure of 23.60 kilos. (51 lbs.) of soda, an incontestable proof that a notable quantity of soda, ill-retained by the silica, has either disappeared during the conversion in the form of vapor, or has combined with the iron in the form of sodium.

As to the phosphorus, we find the results: Phosphorus in the pig, 10.22 kilos. (22.4 lbs.); phosphorus retained by the cakes, 4.29 kilos. (9 lbs.); phosphorus eliminated, 5.93 kilos. (13 lbs.); a weight which corresponds to 13.48 kilos. (2.96 lbs.) of phosphoric acid. Now the 62 kilos. (136 lbs.) of slag, which yielded 0.158 of phosphoric acid, contain 9.80 kilos. (21.4 lbs.); and this, too, must be taken as a maximum. So not more than two-thirds of the phosphorus eliminated are really retained by the slag. There is, consequently, still a loss by volatilization, but it is not nearly so great as in the case of the Hayanges pig. There the soda, more entangled by the silica, acts less energetically on the phosphoric acid. We have here a new proof of the influence of silicious slags on phosphoric compounds at high temperatures.

These considerations will now permit us to investigate the chemical reactions which take place in the Heaton converter, and to explain the very varied phenomena which are exhibited. When the molten metal reaches the nitrate the latter is at once decomposed; the nitric acid is at once reduced to the condition of nitrogen, or protoxide of nitrogen; but there is also formed a little oxide, which we recognize by the reddish vapors which escape from the converter.

The oxygen of the nitre first seizes on the silicon, the phosphorus and the sulphur hold out longer, the carbon longest of all. A part of the sulphur passes into the slag in the form of sulphuret of sodium. Of the metals the manganese, and no doubt also the metallic earths, are to a great extent oxidized; the iron is hardly acted on at all, so long as there is no excess of nitrate used. Only a portion of the oxidized products is found in the slag. The carbon escapes in the form of carbonic oxide. The slag contains no trace of carbonate of soda; the silicon, indeed, transformed into silica, is completely retained in the slag by the soda and other bases. The phosphorus holds an intermediate position between these two substances, both as regards its distribution among the oxidized products and as regards its property of oxidization. Some portion of it forms phosphate of soda; some escapes in the form of vapors more or less oxidized. The relative quantities of phosphate and vapors depend on the degree of saturation of the soda by the silica, and probably, also, on the temperature. If we wish to retain the phosphoric acid, we must not mix silicious sand with the nitrate.

(TO BE CONTINUED.)

Attention is being drawn in different parts of the country to the alterations which the climate of Australia is undergoing, in consequence of the systematic denudation of tree covering which the surface of the conntry is being subjected to. The Government of Victoria have appointed an Inspector of State Forests, whose duty it will be to prevent the waste of timber and the reckless destruction of live wood, and at the same time to establish nurseries of forest trees in various parts of the colony.

RAILWAY RESISTANCE.

From "Engineering."

We have been lately favored with the details of some experiments made on the Southern and Western Railway, of Queensland, in May last, to determine the relative resistances to traction on the various gradients and curves on that line; and although these experiments present certain inconsistencies which render it impossible to deduce from them any precise rule for calculating the resistance due to a curve of any given radius, yet they possess for many of our readers an interest far more than sufficient to entitle them to a record in our pages, and we therefore propose to give an account of them in the present notice. The Queensland railways, of which we gave a description in our last number, are, as most of our readers are aware, of 3 ft. 6 in. gauge, and it is this peculiarity in the gauge which gives the experiments just referred to special interest. The experiments were made by Mr. J. F. L. Jetter, the locomotive superintendent of the line, and they consisted in drawing over the latter, from Murphy's Creek to Troowoomba, at a speed of 10 miles per hour, a train of seven vehicles, the tractive force required at the different portions of the journey being carefully ascertained by means of a dynamometer. The train was made up of six empty wagons and a brake van, the latter containing 10 cwt. of ballast. The weights, etc., of the vehicles are as follows:

	Weight. tons.	cwt.	qrs.		No. of wheels.
Brake van..........	5	14	1	......	4
Covered goods wagon.	3	18	1	......	4
Carriage truck.......	2	15	0	......	4
Covered goods wagon.	5	8	2	......	6
Low sided "	4	19	0	......	6
" "	4	19	0	......	6
" "	4	19	0	......	6
Total gross weight	32	13	0	......	36

We gave particulars of the rolling stock for the Queensland lines, on pages 174 and 196 of our second volume; but we may mention here that the wagons have wheels 2 ft. in diameter, and that the wheel base of the four-wheeled vehicles is 7 ft. The six-wheeled vehicles have, we believe, a wheel base of 15 ft.; but they are fitted with Mr. John Clark's arrangement for enabling the wheels to adjust themselves to curves, so that the long wheel base does not increase the frictional resistance.

With a view of, in the first place, ascertaining what we may call the normal frictional resistance of the Queensland rolling stock, at the speed of 10 miles per hour, we have selected from Mr. Jetter's experiments, those made on the straight portions of the line, and embodied them in the annexed Table, No. I.

TABLE No. I.,

SHOWING THE RESISTANCES ON THE STRAIGHT PORTIONS OF THE LINE.

Weight of Train, 32 tons, 13 cwt. Speed, 10 miles per hour.

Gradient.	Strain on dynamometer in cwts.	Total resistance of train in pounds per ton.	Resistance in pounds per ton due to gravity.	Frictional resistance in pounds per ton.
Level.	5	17.15	...	17.15
1 in 625...........................	5½	18.87	3.58	15.29
1 in 120...........................	10	34.30	18.66	15.64
1 in 98...........................	12	41.16	22.85	18.31
1 in 87...........................	13	44.59	25.74	18.85
1 in 81...........................	13½	46.30	27.65	18.65
1 in 66...........................	15	51.45	33.94	17.51
1 in 60...........................	15	51.45	37.33	14.12
1 in 55...........................	16½	56.60	40.72	15.88
1 in 50...........................	18	61.74	44.80	16.94
Mean frictional resistance in pounds per ton =..............................				16.84

The data given by Mr. Jetter are, the weight of the train, the gradients, and the tractive force required, in cwts., and from the first and last of these data we have

calculated the total resistances of the train, in pounds per ton, as given in the third column of the Table. Deducting from these amounts the resistance due to gravity in each case, we get the remainders given in the last column of the Table, which represent the frictional resistance of the train in pounds per ton. These results, it will be seen, agree very fairly with each other; but their mean, 16.84 lbs. per ton, is certainly extremely high, even when the small diameter of the wheels is considered. To some extent this high frictional resistance may be due to the train being composed of *empty* wagons, the friction of empty railway vehicles being generally slightly greater per ton than that of the same vehicles when loaded; but this cause would only account for a small portion of the resistance, which is most certainly excessive, and can only be caused by some defects in the construction or state of maintenance of the rolling stock. The resistance is, in fact, so high that we should have hesitated to accept the data as correct had not the coincidence in the results obtained on the various gradients shown conclusively the correctness of the dynamometric indications.

The frictional resistance on the straight

TABLE No. II.,

SHOWING THE RESISTANCES ON THE CURVED PORTIONS OF THE LINE.

Weight of Train, 32 *tons* 13 *cwt.* *Speed*, 10 *miles per Hour.*

Reference Number.	Radius of Curve in Chains.	Gradient.	Strain on Dynamometer in cwts.	Total Resistance of Train in Pounds per Ton.	Resistance due to Gravity in Pounds per Ton.	Resistance, in Pounds per Ton, due to Friction—Total Resistance—Resistance due to Gravity.	Resistance due to Curve in Pounds per Ton—Total Resistance—(Mean Frictional Resistance on Straight Line+Resistance due to Gravity.
1	57½	1 in 120	11	37.74	18.66	18.08	2.24
2	20	1 " 88	15	51.45	25 45	26.00	9.16
3	20	1 " 60	16	54.88	37.33	17.55	0.71
4	15	1 " 50	20	68.60	44.80	23.80	6.96
5	12	1 " 60	17	58.31	37.33	20.98	4.14
6	10	1 " 100	13½	46.30	22.40	23.90	7.06
7	10	1 " 50	19	65.17	44.80	20.37	3.52
8	9½	1 " 80	14	48.02	28.00	20.02	3.18
9	9	1 " 50	21	72.03	44.80	27.23	10 39
10	8	1 " 112	12	41.16	20.00	21 16	4.32
11	8	1 " 60	16	54.88	37.33	17 55	0.71
12	8	1 " 50	19½	66 89	44.80	22.09	5.25
13	7	1 " 226	10	34.30	9.91	24.39	7.55
14	7	1 " 110	13	44.59	20.36	24.23	7.49
15	7	1 " 50	21	72.03	44.80	27.23	10.39
16	6½	1 " 50	22	75.48	44.80	30.68	13.84
17	6	1 " 80	14	48.02	28.00	20.02	3.18
18	6	1 " 50	22½	77.18	44.80	32.38	15.54
19	5½	1 " 71	16	54.88	31.55	23.33	6.49
20	5½	1 " 64	16½	56.60	32.50	24.10	7.26
21	5½	1 " 60	17½	60.03	37.33	22.70	5.86
22	5	Level.	6	20.58	.....	.....	3.74
23	5	1 " 625	7	24.01	3 58	20.43	3.59
24	5	1 " 300	8	27.44	7.47	19.97	3.13
25	5	1 " 110	14	48.02	20.36	27.66	10.82
26	5	1 " 105	14	48.02	21.33	26.69	9.85
27	5	1 " 100	14	48.02	22.40	25.62	8.78
28	5	1 " 80	16	54.88	28.00	26.88	10.04
29	5	1 " 74	18	61.74	30.26	31.48	14 64
30	5	1 " 65	19	65.17	34.46	33.71	13.87
31	5	1 " 60	21	72.03	37.33	34.70	17.86

portions of the line being ascertained, the increase in that resistance due to the various curves can be readily determined from Mr. Jetter's other experiments, the details of which are included in the first four columns of Table No. II. From these data, we have, as before, calculated the total resistance of the train in pounds per ton (*vide* fifth column of the Table), and deducting from these amounts the resistance due to gravity in each case, we get the frictional resistances on the various curves as given in the seventh column of the Table. Deducting again from these last-mentioned resistances the normal frictional resistance on the straight portions of the line, as before determined, we get the remainders included in the last column of the Table, these representing the increase in the normal frictional resistance (in pounds per ton) due to the various curves, of which the radii, in chains, are given in the second column of the Table.

TABLE No. III,

SHOWING THE INCREASE OF FRICTIONAL RESISTANCE DUE TO CURVATURE.

Gauge of Line, 3 *ft.* 6 *in.* *Train consisting of seven vehicles weighing* 32 *tons,* 13 *cwt. gross.* *Speed,* 10 *miles per hour.*

Radius of curves in chains.	Number of experiments from which the results are deduced.	Increase in frictional resistance due to curvature, expressed in pounds per ton. Value, deduced from Table No. II.		
		Maximum.	Minimum.	Mean.
57½	1	2.24	2.24	2.24
20	2	9.16	0.71	4.93
15	1	6.96	6.96	6.96
12	1	4.14	4.14	4.14
10	2	7.06	3.52	5.29
9½	1	3.18	3.18	3.18
9	1	10.39	10.39	10.39
8	3	5.25	0.71	3.42
7	3	10.39	7.49	8.48
6½	1	13.84	13.84	13.84
6	2	15.54	3.18	9.36
5½	3	7.26	5.86	6.54
5	10	17.86	3.13	9,63

For convenience of reference, we have embodied the various amounts, representing the increase in the frictional resistance on curves, in the preceding Table No. III., and it will be noticed that they present some striking inconsistencies. It will be seen that, in the first place, there is a considerable variation between the increase in the frictional resistance obtained in different instances on curves of the same radii, the maximum being in several cases over five times—and in one instance over twelve times—the minimum value. Again, the increase of the frictional resistance on the sharper curves is, in many cases, less than that observed on those of larger radius; but this is probably due to some of the curves being so short that the resistance on them was not fairly ascertained. Indeed, Mr. Jetter expressly states in his report that many of the curves on the main line are so short that to obtain accurate results was a difficult matter, and he further says, that the results only hold good for curves of short radius which do not exceed 10 chains in length. He states that if the curve exceeds 10 chains in length the tractive force necessary at the end of the curve is much increased. At the end of a 5 chain curve, of which the length was 18 chains, and gradient 1 in 60, the tractive force required was 22 cwt., instead of 21 cwt., as given in the Table. Altogether, therefore, as we stated at the commencement of the present notice, Mr. Jetter's experiments do not afford sufficient data to enable us to form any definite rule for the increase of the resistance on curves of railways laid to the 3 ft. 6 in. gauge; but they nevertheless possess considerable interest, and they may, moreover, serve

as a nucleus, to which some of our readers may be able to add the particulars of other experiments of a similar kind.

CONCRETE STONE IN INDIA.

From "The Mechanics' Magazine."

All who are acquainted with Bombay are well aware how badly it is off for good building stone. The materials in ordinary use are trap and Porebunder stone, the former of which gives a heavy ponderous appearance to the buildings, whilst the latter is of a very perishable nature. The Coorla stone is much more durable, but it is so hard as to be almost unworkable. The stone from Hemnuggur answers well, but the cost of transit is so great as to preclude its use in all but very special cases. Hence the want of a good and cheap building material has been long and seriously felt in Bombay. That want, we are glad to find, is now supplied by the introduction of Mr. Ransome's silicious stone. The value of this invention having become known to the Secretary of State, the manufacture of the Ransome stone was forthwith directed to be carried out at the Government Works in Bombay. An establishment was organized by Mr. A. Pye-Smith, a gentleman from the inventor's works at East Greenwich, and is now in full work, producing stone on Mr. Ransome's beautiful principle. The new stone appears to afford much satisfaction, and the prospect of a material at once pleasant in color, enduring in texture, and moderate in price, is especially cheering where such serious drawbacks as those to which we have referred exist. The introduction of the stone, too, is singularly opportune, inasmuch as the Government is just commencing a series of large buildings, which it was wished to make as permanent as possible. The Ransome stone—as our readers are for the most part aware—is produced by dissolving flints in caustic soda and mixing the resulting silicate of soda with dry silicious sand and limestone powder. The paste thus formed is moulded to any desired shape, and then hardened by immersion in a solution of chloride of calcium. A shower bath of cold water drives off the chloride of sodium, and the stone, after being dried, is ready for use.

Our readers will doubtless remember, from our description of the Ransome's Stone Works at East Greenwich, that the process of saturation with the solution of chloride of calcium is accomplished by hose playing on the block, as well as by immersion. Mr. Ransome has, however, improved this part of the process, and in connection with his son, Mr. Ernest Ransome, and the well-known Mr. Bessemer, has recently obtained another patent, in which is claimed the "saturating, washing, and drying blocks or moulded pieces of artificial stone by means of a vacuum or pressure, or by both vacuum and pressure combined." And the works have now been fitted up with air pumps and other apparatus for this purpose with the most satisfactory result. In the Government Works at Bombay, Mr. Pye-Smith has introduced another very ingenious arrangement for carrying out this part of this process, consisting of an air-tight iron chest, into the upper side of which a pipe is carried from a tank placed at a considerable height above the building. The chest has a movable bottom, which is lowered by a winch and placed on a traveller. When the plate has been loaded with moulded material—the pieces being placed over vents made in the movable bottom—it is placed beneath the saturator, which somewhat resembles a diving bell. It is then screwed up in its place and well packed, the cock of the down pipe is then opened, and the chloride of calcium admitted under the pressure of a good head. It rapidly permeates the soft masses exposed to its action and converts them into durable stone, after which they are treated with water in the usual way. The only drawback the manufacture at first experienced was the difficulty of obtaining sand of the proper quality. There is no silicious sand in or near Bombay, but after several journeys, Mr. Smith found a supply at Kutch Mandive. The limestone powder is readily obtained by pounding Porebunder stone to a sufficient degree of fineness. The natural materials being thus formed, the manufactered ingredients,

such as the silicate of soda and chloride of calcium, are readily obtainable, and thus enable this important manufacture to be developed where it will prove of the greatest value. It supplies a want created by the absence of natural stone of the proper quality for building purposes, and bears striking testimony to the special merit of Mr. Ransome's invention.

ON THE DETERMINATION OF THE REAL AMOUNT OF EVAPORATION FROM THE SURFACE OF WATER.*

By MR. ROGERS FIELD, B.A., AND MR. G. J. SYMONS.

The determination of the amount of evaporation from a water surface would appear at first sight a very simple problem; but that it is really by no means such, is shown by the extremely discordant results arrived at hitherto by the highest authority. To take two instances: Mr. Fletcher, M. P., F. R. S., of Tarn Bank, who is too well known as a careful observer to require that more than his name should be mentioned, and Mr. Proctor of Barry, whom Mr. Buchan describes as one of the ablest observers of the Scottish Meteorological Society. The returns from these two stations are generally in the ratio of 3 to 1; *e. g.*, in 1864, Tarn Bank, 44.23 in.; Barry, 11.09 in.; and in 1865, Tarn Bank, 47.86 in.; and Barry, 28.65 in. The high values returned by Mr. Fletcher do not result from any oversight, because a year or two since he concluded a note on evaporators in the following words: "The mean evaporation is 47 in., a quantity vastly in excess of the amount arrived at by Mr. Howard (20 in.) and Dr. Miller (30 in.), but I believe it to be more correct than either."

Some difference might be expected in the results arrived at, in consequence of the difference of locality; but such startling differences can, we believe, only be explained by the very faulty nature of the evaporators in common use.

Professor Daniell, in his "Meteorological Essays," refers to the ordinary evaporators in the following terms:

"The notion that these afford the absolute measure of the quantity of water raised into the air is absurd, for the instrument can only give the amount of evaporation from the shallow body of water in the place where it has been fixed. The conditions which modify the process vary almost *ad infinitum;* they vary on the land and on the water, they vary in the sunshine and in the shade, they vary as the land is more or less clothed with vegetation, or as the water is more or less deep. The evaporating gauge, so far from representing the circumstances of those bodies which yield the great body of vapor on the earth's surface, probably does not correspond in all essential particulars with a dozen puddles in the course of the year, and the pains which are often taken to make the results tally with those of the rain gauge, or to compare the two, are wholly misdirected." Similar condemnation has been passed by other authorities.

Professor Daniell proposes, as a substitute, two methods of calculating the amount of evaporation from observations of his dew point hygrometer; but he states that it depends on the observer's estimate of the force of the wind. We do not understand why the evaporation from the moistened surface of the hygrometer bulb does not proceed *pari passu* with that from a water surface; but, assuming it to be so, there is little probability that the force at the time of observation would be exactly the average of the day, or that it would be accurately estimated. Even Professor Daniell admits that the amount deduced by this method may exceed or fall short of the tabulated quantity to the extent of one-fourth. We venture, therefore, to consider this plan so inaccurate as to be practically useless.

In this interim note we do not propose discussing the various methods hitherto proposed, but not one of which has been generally adopted; even the best pattern of evaporator, to which we shall hereafter refer as the ordinary evaporator, is not used by one observer in twenty.

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* British Association.

The great objection to nearly all evaporators hitherto used has been their diminutive size, and the consequent fact that the pint or two of water they contain has become unduly heated, and therefore the recorded evaporation has been largely in excess of what it would have been had this artificial elevation of temperature not been produced.

The only published experiments with evaporators of large size, of which we are aware, are those made some years since at Dijon and other places on the Burgundy Canal, recorded in the "Annales des Ponts et Chausées." The evaporators used in these experiments consisted of square masonry tanks about 8 ft. on each side, and 1 ft. 4 in. deep. They were lined with zinc so as to be perfectly water-tight, and sunk in the ground. The amount of evaporation from these tanks was found to be less than half what was generally adopted by the best authorities as the evaporation in that district. Experiments were also made during one year with an evaporator 1 ft. square by the side of the large ones, and the evaporation in this case was found to be some 50 per cent. greater in the smaller than in the larger tank.

Professor Haughton, of Trinity College, Dublin, has published, in the Proceedings of the Royal Irish Academy, some observations on evaporation at St. Helena, by Major Phillips and Lieutenant Haughton, which, though on a smaller scale, have an important bearing on the question. These experiments were made with two different kinds of evaporators placed near each other: (1) a glass cylinder 9 in. high and 9.85 in. in diameter, fully exposed, and (2) a similar glass cylinder, placed in a large tub of water so as to have the water inside the cylinder always surrounded by water nearly the same level. In these experiments, carried on for two years, the evaporation from the exposed cylinder was found to be nearly 50 per cent. greater than that from the cylinder surrounded by water. In both the above quoted instances, the small evaporators which gave an excessive amount of evaporation were better and less liable to become unduly heated than those ordinarily in use, which may, therefore, be reasonably assumed to give still more erroneous results.

There can be no question that the most accurate method of arriving at the evaporation from a water surface is by observation on large tanks, as at Dijon; but we cannot hope that apparatus of this kind will be used save in exceptional cases, and it therefore becomes important to devise some simple arrangement which should give approximately correct results. Our own experiments having only recently been commenced, we by no means consider that we have overcome all the difficulties of the subject; but we desire to place upon record a few facts which we hope may act as incentives to further and more complete researches on this very important subject.

One fact, which partly explains the comparative neglect into which this subject has fallen, is the difficulty of measuring accurately the quantity of water abstracted, the process usually consisting in measuring the whole volume with a graduated glass; and this is also probably one reason for the small capacity of many of the evaporators, some holding only one inch deep of water.

This difficulty has been entirely obviated in our experiments by the use of a small instrument called a "hook gauge," designed sometime since by Mr. Field, as a portable instrument for purposes of hydraulic observations. The principle is borrowed from an elaborate fixed arrangement described in Francis's "Lowell Hydraulic Experiments." All other known methods of observing the height of the surface of still water are interfered with by the effects of capillary attraction, whereas this instrument owes its great precision to that phenomenon. If the point of the hook is ever so slightly raised above the water surface, it raises a small cone of water with it, which is at once rendered visible by the distortion of the reflection. If, on the other hand, the point is depressed below the water, it carries the water down with it, and forms a depression, which also causes distortion of the reflection. It is, therefore, only necessary to adjust the hook so that there shall be no distortion, and the point will then be precisely level with the surface of the water. A vernier on the slide enables the depth to be read to $\frac{1}{100}$ in. with undeviating certainty. There is a clamped bar attached, by adjusting which, and resting it on the top of the evaporator, the zero thereof can be placed in any convenient

position, without the necessity of having a fixed point for the zero at the bottom of the vessel.

The arrangements we have adopted are shown on the diagram.

Fig. 1. represents, perhaps, one of the best forms of ordinary evaporators, many of those used even by the highest authorities (such as Luke Howard) being much more objectionable. It will be seen that it consists of a copper vessel containing about a quart of water exposed to direct and reflected heat on every side, and even on the bottom, so that if it were required to obtain the maximum temperature to which that volume of water could be raised by the solar beams, the arrangements could hardly be improved upon.

Fig. 2. represents an arrangement designed by Mr. Symons some months since, wherein the vessel, still of metal, is sunk almost wholly into the ground, so as to obviate as far as possible artificial heating.

Fig. 3. is a modification of the plan adopted by Major Phillips, at St. Helena, and already referred to. In this, the water to be measured is contained in a glass cylinder, which is placed in the centre of a much larger vessel of water, the whole being buried in the earth up to the brim of the large vessel.

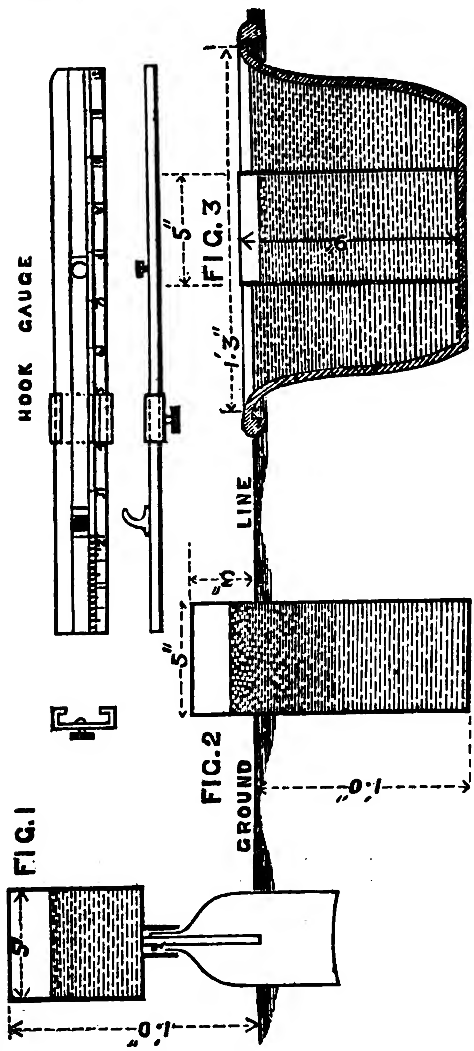
The following Table gives the detailed results of our observations :

Evaporation during part of July and August, 1869. (*Camden square, London,* 111 *ft. above Sea Level.*)

Date of Reading.	Evaporation in hours stated.				Evaporation in 24 hours.				Temperature of water.		
	Total hrs.	Casellas.	Symons.	Phillips.	Casellas.	Symons.	Phillips.	Computed from hygrometer.	Casellas.	Symons.	Phillips.
		in.	2 in.	3 in.	1 in.	2 in.	3 in.	in.	Deg.	Deg.	Deg.
July 22, 9 A. M.	24	.18	.16	.13	.18	.16	.13	.17	82.8	77.9	74.0
" 22, 2 P. M.	5	.19	.08	.04	..	..	..	..	95.8	86.4	82.1
" 23, 9 A. M.	19	.18	.17	.14	.37	.25	.18	.30	..	..	..
" 24, 9 A. M.	24	.18	.15	.08	.18	.15	.08	.19	79.4	74.2	73.8
" 25, 9 A. M.	24	.32	.25	.20	.32	.25	.20	.18	75.0	73.8	73.2
" 25, 9 P. M.	12	20	.11	.14	..	..	..	..	83.4	79.8	76.0
" 26, 9 A. M.	12	.05	.06	.03	.25	.17	.17	.22	..	..	..
" 26, 1 P. M.	4	.12	.06	.05	..	..	..	..	..	..	..
" 26, 6 P. M.	5	.12	.08	.04	..	..	..	..	..	..	..
" 27, 9 A. M.	15	.05	.06	.08	.29	.20	.17	.17	..	..	..
" 27, 2 P. M.	5	.16	.05	.06	..	..	..	..	82.1	77.8	73.9
" 28, 9 A. M.	19	.11	.09	.06	.27	.14	.12	.10	..	..	..
" 29, 9 A. M.	24	.09	.12	.03	.09	.12	.03	.06	..	..	..
" 29, 1 P. M.	4	.04	.03	.02	..	..	..	..	79.2	72.2	71.8
" 30, 9 A. M.	20	.20	.12	.12	.24	.15	.14	.15	..	..	..
" 30, 7 P. M.	10	.11	.06	.06	..	..	..	..	..	..	..
" 31, 9 A. M.	14	.05	.04	.03	.16	.10	.09	.16	..	..	..
Aug. 1, 9 A. M.	24	.12	.12	.11	.12	.12	.11	.12	80.4	76.1	73.0
" 1, 1 P. M.	4	.08	.05	.02	..	..	..	..	..	..	..
" 1, 6 P. M.	5	.09	.07	.04	..	..	..	..	..	..	..
" 2, 9 A. M.	15	.07	.07	.08	.24	.19	.14	.14	..	..	..
" 2, 3 P. M.	6	.11	.06	.06	..	..	..	..	..	..	..
" 3, 9 A. M.	18	.02	.04	.03	.13	.10	.09	.11	..	..	..
" 4, 9 A. M.	24	.08	.06	.00	.08	.06	.00	.10	..	..	..
" 5, 9 A. M.	24	.19	.08	.10	.19	.08	.10	.16	..	..	..
" 5, 2 P. M.	5	.07	.05	.02	..	..	..	..	72.0	68.1	70.2
" 6, 9 A. M.	19	.10	.10	.12	.17	.15	.14	.21	76.4	71.3	69.5
" 6, 6 P. M.	9	.07	.06	.05	..	..	..	..	..	..	..
" 7, 9 A. M.	15	.06	.04	.03	.13	.10	.08	.21	..	..	..
" 7, 5 P. M.	8	.13	.11	.05	..	..	..	..	..	..	..
" 8, 9 A. M.	16	.06	.06	.07	.19	.17	.12	.11	..	..	..
" 9, 9 A. M.	24	.04	+.01	+.01	.04	+.01	+.01	.06	..	..	..
" 10, 9 A. M.	24	.31	.21	.16	.31	.21	.16	.15	..	..	..
" 11, 9 A. M.	24	.27	.17	.13	.27	.17	.13	.18	..	..	..
" 12, 9 A. M.	24	.15	.10	.09	.15	.10	.09	.14	..	..	..
Total	..	4.37	3.13	2.46	4.37	3.13	2.46	3.39	..	..	..
Ratio	..	..	..	..	1.78	1.27	1.00	1.38	..	..	..

It would be quite premature to draw definite conclusions from the short period of observation hitherto elapsed, but we may point out a few remarkable results.

(1.) During the three weeks ending August 12th, the total evaporation from Fig. 1 was 4.37 in.; from Fig. 2, 3.13 in.; and from Fig. 3, 2.46 in., numbers which are to each other in the ratio of 1.78, 1.27 and 1.00. Fig. 1 therefore lost 78 per cent. more water by evaporation than Fig. 3.



(2.) During the daytime the sunshine heats Figs. 1 and 2 to such an extent that the ratios of evaporation become about 250, 150, and 100.

(3.) During the night there are indications of a slight addition to Fig. 3 from condensed vapor.

(4.) It will be seen that the evaporation as computed from the hygrometer bears no regular relation to any of the others, being sometimes greater than any of them and sometimes less.

We have already pointed out that we consider the accuracy of an evaporator is largely dependent on its capabilities of retaining the temperature of the contained water at as nearly as possible that of large volumes of water, such as reservoirs, rivers, and ponds. Hitherto we have not been able to institute regular comparisons of the temperatures of the water in our experimental vessels with that of the surface of large bodies of water. Surface temperature alone is concerned, because therefrom alone can evaporation take place. On the few instances when we have done so we have found that the water in the water-surrounded glass cylinder (Phillips, Fig. 3) has been nearly identical with that of a rather shallow reservoir one acre in extent. We do not, however, consider our observations sufficiently numerous to prove this. They, however, abundantly prove the faulty nature of all ordinary evaporators, for we find the average temperature at about 2 P.M. to have been in Fig. 1, 80.7 degs.; Fig. 2, 75.8 degs.; Fig. 3, 73.8 degs.; showing an average excess of 7 degs. in the temperature of Fig. 1 over that of Fig. 3. In sunshine there is an excess of twice that amount; in fact, at times the metal becomes so hot as to scorch the hand. Before leaving the subject of temperature we may mention a singular and suggestive fact. The average excess of the temperature in the three vessels above 65 degs. is respectively 15.7 degs., 10.8 degs., and 8.8 degs.; and these values are to one another in the ratio of 1.78, 1.23, and 1.00, or nearly identical with the ratios of the amount of evaporation, viz., 1.78, 1.27, and 1.00.

We commenced this paper by placing in juxtaposition the values assigned by two high authorities in our own country, of which one was thrice the other. We can hardly more strongly advocate the claims of this question to investigation than by quoting, in conclusion, M. Vallès, the French engineer, who first called attention to the great discrepancy between the observations on the canal of Burgundy and

the data generally adopted in France by scientific men. M. Vallès says: "We do not understand how in a country like ours, and with reference to one of the most important of hydraulic data, we can rest content with only knowing that the numerical value to be attributed to this datum, so essential for a large number of engineering works, lies between two limits, one of which is double the other!"

HOW HEAT DISAPPEARS BEHIND A MOVING PISTON.

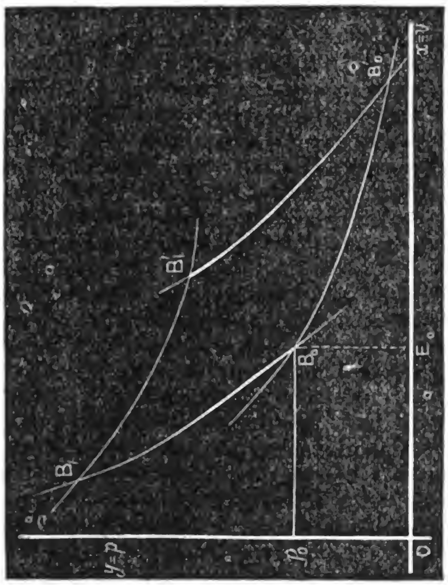
From "The Engineer."

The discovery of the age is acknowledged to be that of the thermal equivalent of mechanical work. It is possible to treat the whole theory of thermal engines—as least as far as is required for engineering purposes—without defining, or trying to define, the nature of the heat. But an hypothesis connecting facts otherwise isolated, closing up the gap preventing that thorough understanding of matters which would indicate progress in fresh directions, must be of the greatest importance, even from a merely practical point of view. By regarding heat, like sound and light, as a mode of motion, a great number of results have been discovered, which although developed—as in the book we review elsewhere—without the use of the hypothesis, could certainly not have been found out without this hypothesis. And it is only since its introduction to the world of science that a theory of heat deserving the name can be spoken of.

The ideal engine—by aid of which heat can be converted into work—merely consists of a cylinder closed at one end and embracing a piston, together inclosing a certain quantity of gas or vapor of any given unit of weight. This amount of gas has a certain volume, which we will call V_0, a certain pressure, P^0, and a certain temperature, t_0. Now, let us suppose the fluid to be compressed by an external force. Its temperature accordingly gets raised until it attains a value we will call t_1. Whilst the temperature and volume get altered by this compression, the pressure is increased according to a certain law, so that to each stage of volume and temperature there corresponds a certain pressure. This law of increase may be most plainly indicated by the accompanying diagram, first used for the purpose by Clapeyron. In this we set off on the horizontal axis, OX, the volumes; and on the vertical axis, OY, the corresponding pressures. By well-known rules, a certain point on our diagram corresponds to certain stages of temperature, volume, and pressure of gas in our cylinder; and hence the position of the point in question changes with the volume and temperature of the gas. Supposing that B^0 is the point corresponding to the original state before the gas was compressed, then this point will move along a curve, B_0 B_1, during compression. During this process it is supposed that no heat was gained or lost by the cylinder. We will now imagine that it is in our power to impart heat to, or to extract heat from, the gas. This is done by an apparatus the generic term for which is heat reservoir. For instance, the fire gases of the boiler furnace form the reservoir of heat in the steam-engine. In the ideal case we are considering we may suppose a reservoir of heat is formed by a medium of a certain temperature surrounding the cylinder, and keeping the temperature of the inclosed gas at a constant height. This surrounding medium we further suppose ourselves to be at liberty to remove. We next assume that when the ideal cylinder is without its reservoir, no heat makes its way either to or from the gas; and this we assume to have been the case with our gas during the compression mentioned above, and which left it at the temperature, t^1. We will now imagine ourselves to apply to our cylinder a reservoir of heat of the same temperature, t^1; and if we allow the gas again to expand, it will *not* be cooled by this expansion. The consequence is, that the pressure does not decrease so rapidly as it otherwise would. This expansion is continued during a certain time, and the reservoir of heat is then taken away, whilst the gas is still allowed to expand. As it cannot take up heat the temperature of the gas will decrease, and, consequently, the pressure will decrease more rapidly than before. As soon as the gas has cooled down to our lowest original tem-

perature, t^o, we surround the cylinder by another reservoir of heat having this temperature, t^o, and we again begin to compress the gas to the original volume. During this compression the temperature would increase if we had not applied our reservoir. But the reservoir takes up this heat, and thus our gas arrives at its original volume and its original temperature, and, consequently, its original pressure.

Returning more particularly to the diagram, we have to trace the four different stages of the process undergone by the inclosed gas. During the first stage of this process the point representing volume and pressure moved from the point B_0 to B_1. During the second stage, a similar curve, B_1 B', will be described; but as the pressure does not decrease so rapidly as it increased before, this curve will fall above the other one. During the third stage, while the temperature decreases, a curve, B'_1 B'_0, is described parallel to the first one, and during the last our



point moves back from B'_0 to the initial point B_0; thus our four curves inclose an area, B_0 B_1 B'_1 B'_0 B_0, which represents the *work done* during the whole process, exactly as the work done during a stroke of the piston is represented in an ordinary Watt's Indicator diagram.

During the second part of the process, whilst the reservoir of the high temperature, t_1, was applied, heat was taken up into the cylinder, and during the last process the other reservoirs of the low temperature, t_0, took up heat from the gas. During the process heat passes into the cylinders from a hot reservoir, and heat flows into one of a lower temperature.

This was already known to Clapeyron, the inventor, in 1834, of this diagram; but the original indication that heat can only do work by flowing from a hotter body to a cooler one is due to S. Carnot, the son of the great French Minister of War and mathematician of that name. It is clear, for instance, that it would be impossible to work an engine in an atmosphere having the temperature of the steam with which it is supplied. In such a case our diagram would shrink up to a single line, inclosing no area at all, and therefore indicating no work. If we suppose an atmosphere hotter than the steam, we should have to do external work to get the engine into motion; the steam would have to be pumped out of the boiler into the atmosphere. In the ideal engine we have supposed, it is possible by doing work to extract heat out of the cooler reservoir and to impart it to the hotter one.

According to Clapeyron, *no* heat was transformed in the engine whilst doing work; and accordingly he supposed that the quantities of heat taken up and given off during the cycle of its progress through the engine were equal. But in reality heat actually disappears in producing work, it actually disappears behind the moving piston of a steam-engine; a physically demonstrable fact that cannot be at all explained on the caloric theory that heat is a fluid. It was therefore necessary to find out another hypothesis more suited to the facts. In 1842, Dr. Mayer, of Heilbronn, clearly pointed out, not only that heat is actually lost, but that always the same amount of heat disappears in doing a given amount of work, or that there exists a mechanical equivalent of heat. The same thing was done in the course of the following year by A. Colding, an engineer of Copenhagen. At the same time Dr. Joule, of Manchester, independently of both, began his experiments on this subject. By the hypothesis linking together a great number of natural phenomena, the *vis viva* of the molecules, which is heat, is transferred into *vis viva*, or work

accumulated in the piston, and visibly appearing in its motion.

According to the doctrine of the thermal equivalent of work, the amount of heat disappeared in our engine depends only on the work done; but it is another question, whether the amount of heat which flows uselessly into the cooler reservoir is always the same. And here the mechanical theory of heat steps in and shows that this depends upon the temperature of the two reservoirs. It diminishes with the temperature of the cooler reservoir, and the amount which passes into the cooler body can never be zero, except in case that this cooler body has the exceedingly low temperature of 273° Cent. below freezing point. These figures appear a little paradoxical, but are easily explained. The amount of *vis viva* of the molecules determines the temperature; and when this *vis viva* is zero there is no heat. The German Professor Clausius has demonstrated that at this temperature—of course unapproached and unapproachable in this universe—there can be no motion of the particles, and therefore no heat. Clausius consequently calls this temperature the absolute zero; and in the mechanical theory of heat the scale of the thermometer, so to speak, is counted from this zero. If we could cool down the temperature of our reservoir of heat to this point, our engine could convert all heat of a hotter reservoir into work. Comparing our ideal engine with the common steam-engine, we find that in both cases we have a cylinder; but in the practical instance we have the steam passing, as the vehicle of the heat, through the cylinder, whilst in the ideal thermal engine we had the heat by itself. In the steam-engine our two reservoirs of heat are the furnace and the atmosphere, or a special condenser, which takes up the heat flowing out of the engine; the ordinary indicator diagram being accordingly different to Clapeyron's theoretical diagram. The inlet of the steam at the first moment corresponds to the first stage of the process of the ideal engine, represented by the line B_1 B'^0, but becoming an almost vertical line in the steam-engine. The straight horizontal line corresponds to the line B_1 B'^1; and the line during expansion corresponds to B'_1 B'^0. The exhaust of the steam would give the curve B'^0 B^0; and it is clear, as all is going on continuously in the steam-engine, we cannot have the sharp corners of the Clapeyron curve. The heat passing, together with the steam, into the cylinders, may, with regard to its mechanical effect, be divided into two parts—into the heat converted into actual work, and into that which, even theoretically, necessarily must pass into the condenser or atmosphere; without counting, of course, the numerous practical losses by induction, condensation on chilled surfaces, conduction, and others. The proportion of the loss of this second part to the whole becomes less by an increase of the difference of temperature between the boiler and the atmosphere. In the condenser we regain some of the work formerly used to convert the water into steam. Hence a steam-engine will work all the more economically, as regards the expenditure of coal, the higher the temperature of the steam, and the lower the temperature at which it leaves the cylinders.

The general principles illustrated by the diagram are, therefore, first, that heat can only work by passing from a hotter, through an engine, to a cooler body; and, secondly, that during this passage one portion of the heat is converted into work, whilst another portion actually passes over into the cooler body.

The artillery experiments at Finspong, in Sweden, have now been completed, and the Danish Minister of War, M. Raasloff, has returned to Copenhagen. The new 11¼ in. gun, which is made entirely of Swedish iron, has met with general approval both among Swedish and Danish artillerists. It was fired from a distance of 580 ft. at a target made of six plates of iron, each 2 in. thick, and backed with strong wooden beams. About 20 yards behind it was a wooden target 2 ft. thick, leaning against an embankment of gravel. The conical projectile of the gun, weighing 150 lbs., pierced both targets and buried itself to a depth of 8 ft. in the embankment.

Sir John Herschel calculates that the great pyramid weighs 12,760,000,000 lbs. Lyall gives a larger estimate of 6,000,000 tons. According to Perring, the present quantity of masonry is 6,316-000 tons, or 82,110,000 cubic ft.

ENGINEERING PROGRESS.

From "The Practical Mechanic's Journal."

An Abstract of an address delivered before the Mechanical Science Section of the British Association, by Mr. G. W. SIEMENS, President of the Section.

In viewing the latest achievements of engineering science, two works strike the imagination chiefly by their exceeding magnitude, and by the influence they are likely to exercise upon the traffic of the world. The first of these is the great Pacific Railway, which, in passing through vast regions hitherto inaccessible to civilized man, and over formidable mountain chains, joins California with the Atlantic States of the great American Republic. The second is the Suez shipping canal, which, notwithstanding adverse prognostications and serious difficulties, will be opened very shortly to the commerce of the world. These works must greatly extend the range of commercial enterprise in the North Pacific and the Indian Seas. The new water-way to India will, owing to the difficult navigation of the Red Sea, be in effect only available for ships propelled by steam, and will give a stimulus to that branch of engineering. Telegraph communication with America has been rendered more secure against interruption by the successful submersion of the French Transatlantic cable. On the other hand, telegraphic communication with India still remains in a very unsatisfactory condition, owing to imperfect lines and divided administration. To supply a remedy for this public evil, the Indo-European Telegraph Company will shortly open its special lines for Indian correspondence. In Northern Russia the construction of a land line is far advanced, to connect St. Petersburg with the mouth of the Amoor river; on the completion of which, only a submarine link between the Amoor and San Francisco will be wanting to complete the telegraphic girdle round the earth. With these great highways of speech once established, a network of submarine and aerial wires will soon follow, to bind all inhabited portions of our globe together into a closer community of interests, which, if followed up by steam communication by land and by sea, will open out a great and meritorious field for the activity of the civil and mechanical engineer. But while great works have to be carried out in distant parts, still more remains to be accomplished nearer home. The railway of to-day has not only taken the place of high roads and canals for the transmission of goods and passengers between our great centres of industry and population, but is already superseding by-roads leading to places of inferior importance; it competes with the mule in carrying minerals over mountain passes, and with the omnibus in our great cities. If a river cannot be spanned by a bridge without hindering navigation, a tunnel is forthwith in contemplation; or, if that should not be practicable, the transit of trains is yet accomplished by the establishment of a large steam ferry. It is one of the questions of the day to decide by which plan the British Channel should be crossed, to relieve the unfortunate traveller to the continent of the exceeding discomfort and delay inseparable from the existing most imperfect arrangements. Considering that this question has now been taken up by some of our leading engineers, and is also entertained by the two interested Governments, we may look forward to its speedy and satisfactory solution. So long as the attention of railway engineers was confined to the construction of main lines, it was necessary for them to provide for a heavy traffic and high speeds, and these desiderata are best met by a level permanent way, by easy curves and heavy rails of the strongest possible materials, namely, cast-steel; but in extending the system to the corners of the earth, cheapness of construction and maintenance, for a moderate speed and a moderate amount of traffic, becomes a matter of necessity. Instead of plunging through hill and mountain, and of crossing and recrossing rivers by a series of monumental works, the modern railway passes in zigzag up the steep incline, and conforms to the windings of the narrow gorge; it can only be worked by light rolling stock of flexible construction, furnished with increased power of adhesion and great brake power. Yet by the aid of the electric telegraph, in regulating the progress of each train, the number of trains may be so increased as to produce, nevertheless, a large aggregate of traffic; and

it is held by some that our trunk lines even would be worked more advantageously by light rolling stock. The brake power on several of the French and Spanish railways has been greatly increased by an ingenious arrangement, conceived by M. Le Chatelier, of applying what has been termed "contre vapeur" to the engine, converting it for the time being into a pump, forcing steam and water into the boiler. While the extension of communication occupies the attention of, perhaps, the greater number of our engineers, others are engaged upon weapons of offensive and defensive warfare. We have scarcely recovered our wonder at the terrific destruction dealt by the Armstrong gun, the Whitworth bolt, or the steel barrel consolidated under Krupp's gigantic steam-hammer, when we hear of a shield of such solidity and toughness as to bid defiance to them all. A larger gun or a harder bolt by Palliser or Grüsen is the successful answer to this challenge; when, again, defensive plating, of greater tenacity to absorb the power residing in the shot, or of such imposing weight and hardness combined as to resist the projectile absolutely (causing it to be broken up by the force residing within itself), is brought forward. The ram of war, with heavy iron sides, which a few years since was thought the most formidable, as it certainly was the most costly, weapon ever devised, is already being superseded by vessels of the *Captain* type, as designed by Captain Coles, and ably carried out by Laird Brothers, with turrets (armed with guns of gigantic power) that resist the heaviest firing, both on account of their extraordinary thickness and of the angular direction in which the shot is likely to strike. By an ingenious device, Captain Moncrieff lowers his gun upon its rocking carriage after firing, and thereby does away with embrasures (the weak places in protecting works), while at the same time he gains the advantage of reloading his gun in comparative safety. It is presumed that in thus raising formidable engines of offensive and defensive warfare, the civilized nations of the earth will pause before putting them into earnes operation; but if they should do so, it is consolatory to think that they could not work them for long without effecting the total exhaustion of their treasuries, already drained to the utmost in their construction. While science and mechanical skill combine to produce these wondrous results, the germs of further and still greater achievements are matured in our mechanical workshops, in our forges, and in our metallurgical smelting works; it is there that the materials of construction are prepared, refined, and put into such forms as to render greater and still greater ends attainable. Here a great revolution of our constructive art has been prepared by the production, in large quantities and at moderate cost, of a material of more than twice the strength of iron, which, instead of being fibrous, has its full strength in every direction, and which can be modulated to every degree of ductility, approaching the hardness of the diamond on the one hand, and the proverbial toughness of leather on the other. To call this material cast-steel seems to attribute to it brittleness and uncertainty of temper, which, however, are by no means its necessary characteristics. This new material, as prepared for constructive purposes, may indeed be both hard and tough, as is illustrated by the hard steel rope that has so materially contributed to the practical success of steam-ploughing. Machinery steel has gradually come into use since about 1850, when Krupp, of Essen, commenced to supply large ingots that were shaped into railway tyres, axles, cannon, etc., by melting steel in halls containing hundreds of melting crucibles. The Bessemer process, in dispensing with the process of puddling, and in utilizing the carbon contained in the pig-iron, to effect the fusion of the final metal, has given a vast extension to the application of cast-steel for railway bars, tyres, boiler-plates, etc. This process, however, is limited in its application to superior brands of pig-iron, containing much carbon and no sulphur or phosphorus, which latter impurities are so destructive to the quality of steel. The puddling process has still, unless the process of decarburization of Mr. Heaton takes its place, to be resorted to, to purify these inferior pig-irons, which constitute the bulk of our productions; and the puddled iron cannot be brought to the condition of cast-steel except through the process of fusion. This is accomplished successfully in masses of from 3 to 5 tons on the open bed of a regenerative furnace at the Landore Siemens Steel Works, and at

other places. At the same works cast-steel is also produced, to a limited extent as yet, from iron ore, which, being operated upon in large masses, is reduced to the metallic state and liquefied by the aid of a certain proportion of pig metal. The regenerative gas furnace—the application of which to glass-houses, to forges, etc., has made considerable progress—is unquestionably well suited for this operation, because it combines an intensity of heat, limited only by the point of fusion by the most refractory material, with extreme mildness of draught and chemical neutrality of flame. These and other processes of recent origin tend toward the production, at a comparatively cheap rate, of a very high-class material that must shortly supersede iron for almost all structural purposes. As yet engineers hesitate, and very properly so, to construct their bridges, their vessels, and their rolling stock of the material produced by these processes, because no exhaustive experiments have been published as yet fixing the limit to which they may safely be loaded in extension, in compression, and in torsion, and because as yet no sufficient information has been obtained regarding the tests by which their quality can best be ascertained. This great want is in a fair way of being supplied by the experimental researches that have been carried on for some time at her Majesty's dockyards at Woolwich, under a committee appointed for that purpose by the Institution of Civil Engineers. The president had also the pleasure to announce an elaborate report by Mr. Wm. Fairbairn on this subject. In the meantime excellent service has been rendered by Mr. Kirkaldy in giving us, in a perfectly reliable manner, the resisting power and ductility of any sample of material which we wish to submit to his tests. The results of Mr. Whitworth's experiments, tending to render the hammer and the rolls obsolete by forcing cast-steel, while in a semi-fluid state, into strong iron moulds by hydraulic pressure, are looked upon with great interest. But, assuming that the new building material has been reduced to the utmost degree of uniformity and cheapness, and that its limits of strength are fully ascertained, there remains still the task for the civil and mechanical engineer to prepare designs suitable for the development of its peculiar qualities. If in constructing a girder, for example, a design were to be adopted that had been worked out for iron, and if all the scantlings were simply reduced in the inverse proportion of the absolute and relative strength of the new material, as compared with iron, such a girder would assuredly collapse when the test weight was applied, for the simple reason that the reduced sectional area of each part, in proportion to its length, would be insufficient to give stiffness. You might as well almost take a design for a wooden structure, and carry it out in iron by simply reducing the section of each part. The advantages of using the stronger material become most apparent if applied, for instance, to large bridges, where the principal strain upon each part is produced by the weight of the structure itself; for, supposing that the new material can be safely weighted to double the bearing strain of iron, and that the weight of the structure were reduced by one-half accordingly, there would still remain a large excess of available strength in consequence of the reduced total weight, and this would justify a further reduction of the amount of the material employed. In constructing works in foreign parts the reduced cost of carriage furnishes also a powerful argument in favor of the stronger material, although its first cost per ton might largely exceed that of iron.

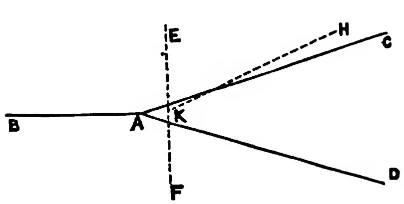
The inquiries of the Royal Coal Commission into the extent and management of the coal-fields appear to be reassuring as regards the danger of their becoming soon exhausted; nevertheless, the importance of economizing these precious deposits in the production of steam power, in metallurgical operations, and in domestic use, can hardly be overestimated. The calorific power residing in a pound of coal of a given analysis can now be accurately expressed in units of heat, which again are represented by equivalent units of force or of chemical action; therefore, if we ascertain the consumption of coal of a steam-engine, or of a furnace employed in metallurgical operations, we are able to tell by the light of physical science what proportion of the heat of combustion is utilized and what proportion is lost. Having arrived at this point we can also trace the channels through which loss takes place, and in diminishing these by judi-

cious improvement we shall more and more approach those standards of ultimate perfection which we can never reach, but which we should, nevertheless, keep steadfastly before our eyes. Thus, a pound of ordinary coal is capable of producing 12,000 Fahrenheit units of heat, which equal 2,240,000 foot-pounds, or units of force; whereas the very best performances of our pumping-engines do not exceed the limit of 1,000,000 foot-pounds of force per pound of coal consumed. In like manner, 1 lb. of coal should be capable of heating 33 lbs. of iron to the welding point of (say) 3,000 deg. Fahr., whereas, in an ordinary furnance, not 2 lbs. of iron are so heated with 1 lb. of coal. These figures serve to show the great field for further improvement that lies yet before us. Although heat may be said to be the moving principle by which all things in nature are accomplished, an excess of it is not only hurtful to some of our processes, such as brewing, and destructive to our nutriments, but to those living in hot climates or sitting in crowded rooms an excess of temperature is fully as great a source of discomfort as excessive cold can be. Why, then, he asked, should we not resort to refrigeration in summer as well as to calorification in winter, if it can be shown that the one can be done at nearly the same cost as the other?

THE BRIDGE OF COURCELLES.

From "The Building News."

Had it not been for the introduction of iron, and its extensive application to railway bridge building, it would have been almost impossible to have manœuvred the modern lines in the tortuous manner many of their routes exhibit. There is a limit to the angle of skew at which an arch of brickwork or masonry may be constructed, but there is practically no limit to the obliquity that may attend an horizontal girder. The latter principle is therefore



the one peculiarly applicable to instances where the angle between the roads above and below the bridge depart much from that of ninety degrees, and that invariably employed by engineers. With the exception of the bridge over La Place de l'Europe, there is not one of the numerous structures of that nature erected in Paris, which has so sharp an angle of skew as the one recently put up at Courcelles, a station on the central railway of the French metropolis. An inspection of the diagram will give a very good idea of the difficulties that M. Clerc, the engineer to the line, had to contend against. The thick lines A D and A C represent two railways which meet at the point of convergence, A; E F and H K show the streets which necessitated the bridge in question; the former being the Rue Brémontier, and the latter the Boulevard Péreire. As a consequence of this convergence of the two roads, it is evident that one bridge had to serve as an abutment for the other. The whole superficial area of the superstructure was not less than three thousand square yards. The general plan adopted was as follows: A triangular pier of masonry was built in the fork where the two railways meet, and two abutments were also erected in the direction of A C and A D. Upon this pier and these abutments was carried the Rue Brémontier, which is 65 ft. in width. The Boulevard Péreire was supported by a bridge, the girders of which rested at one end upon the two abutments already described, and at the other upon the face girder of the bridge, carrying the Rue Brémontier. There are five main girders in this structure, consisting of two outside or face girders, and three inside or intermediate ones. The minimum height of any part of the superstructure above the rails is fixed by the Government at 15.75 feet, and does not not depend upon the height of the funnels of the locomotive, as with us. The reason why a general limit should be imposed, is not quite clear. So long as the bridge is high enough to clear the locomotive un-

derneath, there is not the slightest necessity for making it any higher. It is different when a railway goes over a road. Then it is indispensable to fix some general minimum heading, which, on English lines, is put at 15 ft. for a public road, and 12 ft. for a farm or occupation road.

One of the chief difficulties M. Clerc and his colleague, M. Marin, had to contend against, was the difference of level in the two thoroughfares that had to be taken over the line. This is one of those vexatious points that occasionally arise in construction, and annoy the engineer beyond measure; not so much on account of their presenting any real constructive or scientific difficulty, but from the fact that they render absolutely impossible any attempt at an ornamental or æsthetical design. It is vain to endeavor to combine beauty with abstract utilitarian requirements. The main girders in the Rue Brémontier bridge, which are 243 ft. over all, are not of the same height throughout their whole length, which, but for the cause already mentioned, they would have been. For the same reason the cross girders are much heavier than they need otherwise have been, and the whole effect of the unavoidable condition imposed upon the engineers has been to deprive the structure of that lightness and elegance which under different circumstances would have undoubtedly belonged to it. All the girders, outside as well as inside, are of the lattice type, thus demonstrating that the economy of this principle of bridge construction is understood in France as well as by our own engineers. The diagonal bars in compression, usually termed struts, are of the ordinary channel section, the form of all others the best adapted to resist strains of that nature. Those in tension, or the ties, are plain rectangular bars, which suffice for all purposes where strains of only a tensile character are developed. It is evident that among ourselves the old system of carrying the roadway upon arches of brick, turned between the lower flanges of the girders, is fast becoming obsolete, and Mallet's buckled plates are being substituted as the new *regime*. For strength and lightness there is nothing to compare with them, nor can there be any doubt about their ultimate economy. When that term, however, is used to signify mere saving of money in first cost, they cannot be included under its signification. Hollow brick arches, which are a great deal lighter than solid ones, are still very much patronized by French engineers, and they constitute in the bridge under notice the means for carrying the roadway. Over these is laid concrete, and a coating of asphalte makes everything water-tight.

In order to provide for the expansion and contraction of the main girders, they are free to move on the abutments on cast-iron slides, while they are fastened down to the triangular pier of masonry. Rollers are also placed on the top of the intermediate columns which divide the whole length into smaller spans, upon which they can move freely. The erection of the bridge was accomplished in a double manner. Part of it was put up by the aid of a temporary bridge and scaffolding, and the other part was all riveted together on the adjoining ground, and pushed into its place on rollers. This latter is a method that has been frequently adopted in situations such as a deep ravine, where it is impossible to erect any scaffolding or temporary work. At the same time, it is a serious question whether the force necessary to propel so large a mass of ironwork, may not strain in some degree the structure under its influence. The whole of the iron-work of the bridge of Courcelles was contracted for by the firm of Gouin & Co. The price for the wrought-iron was at the rate of 53 francs per hundred kilogrammes, and for the cast, 25 francs. Reducing to English measures and units, we have the wrought iron at £21 10s. per ton, and the cast at £10 3s.

The Russian newspapers announce that experiments will shortly be made on the Neva with a new invention for propelling ships without using either paddles or screws. The author of this invention is M. Liwczak, an Austrian by birth, who some time ago invented a flying machine propelled by steam, and subsequently became the editor of a Panslavist paper published in Vienna.

The Amazon drains an area of 2,500,000 sq. miles; its mouth is 96 miles wide, and it is navigable 2,200 miles from its mouth.

REPORT ON THE EXPERIMENTS MADE IN PARIS ON THE APPLICATION AND PURIFICATION OF SEWAGE.

From "The Engineer."

An elaborate report on the experiments made at Clichy, near Paris, on the utilization and purification of sewage, has been drawn up by M. Mille and M. Claye, the engineers charged with the management of these important experiments.

These experiments have been entered upon with a full knowledge of what has been done in other countries, and especially in Great Britain, several visits having been made by French engineers and chemists to England, who have evidently studied the subject with their usual acuteness.

The great collector which now receives the waste waters of 66,000 houses, inhabited by nearly two millions of souls, as well as that of a large number of factories, the rainfall and the washings of the public ways, but not the solid excremental matter, empties itself into the Seine at a considerable distance below the city. The experimental establishment at Clichy is situated at about 400 yards from the mouth of the great trunk collector, where the sewer presents the best conditions for a uniform flow, and here the quantity of liquid passing at every hour of the day is carefully gauged by means of floats and staffs. Once a fortnight a brigade of men pass twenty-four hours in the sewer, taking observations every hour. At other times this is only performed twice in the day, namely, at ten in the morning and four in the afternoon; and these observations are afterwards carefully worked out until the results are brought to tally with each other.

It should have been stated above that the series of experiments referred to is now completed, having occupied two years, and an expenditure of nearly £9,000.

To recur to the operations for ascertaining the quantity of liquid passing the sewer, and the rate at which it flows, it may be mentioned that 2,900 observations were made in a period of twelve months, and that the curves of variation are carefully mapped out hourly, daily, and monthly. The general results are as follow: Average, with a liquid depth of one metre, two and one-fifth cubic metres or tons per second, flowing at the rate of 90 centimetres. The maximum result given is that which occurred after a heavy fall of rain, when the volume of liquid reached 45 tons, and the speed 10 metres per second. The total volume passing through the sewer during the year 1868 is stated at 70,000,000 tons; but this only included the sewage of the right bank of the Seine, the connection with the other side of the town not having been made by means of the great siphon of the Seine until November in that year.

The comparison between the quantity of water distributed in Paris, added to the rainfall and the amount passing through the sewer, is important. Average daily district, 213,689 tons; rainfall, 114, 726. Total, 328,415 tons. Average debit of sewer, 190,905, equal to 58 per cent. But here, again, it must be observed the siphon for the left bank was not yet in action. The reporters add, however, that during the cold months the quantity of water carried into the Seine by ordinary channels and lost by infiltration, and especially by evaporation, amounts to about one-third of the whole amount; while during the great heats the proportions are reversed, and only one-third passes into the collector.

In the Seine, as in the Thames, immense deposits are formed at the mouth of the sewer, and dredging machines are frequently at work to break down this bar; while the right bank of the river is bordered by a bed of mud covered with organic matter. What is the amount of this solid matter at present thrown into the Seine, and what is its value as manure? This is the problem which the experiments at Clichy solve theoretically.

In the laboratory or on the grounds the agent employed is alum. The sulphate of alumina is decomposed by the sewage liquid, and converted into a gelatinous substance which carries down with it by its weight the solid matter in suspension, and leaves the water in a few hours almost limpid. This method is borrowed from the Egyptians, Chinese, and other Eastern nations, who use alum to purify turgid water.

Every day two litres of the sewage

water was taken at different times of the day, so as to obtain a fair average result, and the precipitate made by a dose of alum, in the proportion of 2 to 10,000 of the liquid to be acted upon. The precipitate, being collected on the filter and dried, was submitted to chemical analysis.

The result obtained, in the first place, is, that each ton of sewage contains more than 6 lbs. of foreign matter, one-third more of which is in a state of dissolution, and the remaining two-thirds in suspension. This foreign matter is thus given in the report: —Nitrogen, 0.037 kilos. per ton; phosphoric acid, 0.015 kilos. per ton; potash, 0.030 kilos. per ton; soda, 0.101 kilos.; organic matter, 0.729 kilos.; mineral matter, 1.984 kilos. Total, 3.002 kilos.

The sand and other inert matter it will be seen amounts to very nearly two-thirds of the total amount. The precipitate produced by the alum contains nearly half the nitrogen and phosphoric acid and the greater portion of the organic matter, the remainder being left in the purified water, which consequently still retains about half the azote and phosphoric acid, the soluble alkalis, a great part of the lime, and the remainder of the organic matter.

The following is the estimate drawn from the analyses referred to:—Sewage, at 10 cents per ton, 7,000,000f. per annum; or precipitate, at 20f. per ton, 4,000,000f. per annum; clarified liquid, at 6 cents per ton, 3,000,000f. per annum—theoretically, £280,000 thrown annually into the Seine.

As regards the effect on the river the reporters say: As the 70,000,000 tons of sewage annually thrown into the Seine contain 2 kilos. of solid matter per ton, the obstruction, which must constantly be dredged away amounts to 140,000 tons per annum; the bank of mud when uncovered is of a gray tinge, and contains a quantity of straw and other waste matter. In summer fermentation takes place, and the feculent mass poisons the air with its noxious exhalations. This mud is found on analysis to contain all the elements of the precipitate, obtained by means of alum, with the single exception of the phosphoric acid, but in proportion to the distance from the month of the sewer it becomes impoverished as regards nitrogen and organic matter, and finally becomes a mere mineral mass; but, add the reporters, *all that is missing swims in the stream and constitutes the pollution of the river.*

A note relative to the temperature of the sewage deserves notice. During the cold weather of January, when the Seine was frozen, the water in the sewers continued to run with a temperature of about 40 deg., sufficient to melt ice; during the great heat of July, when the Seine was above 75 deg., the sewage was under 68 deg. The contents of the sewer then escapes extreme variations of temperature, and the sewage would warm the land in winter and cool it in the summer.

The experimental works at Clichy were arranged to act upon 500 tons of sewage per day, and the total amount taken out of the sewer during the twelve months ending in November, 1868, was 133,164 tons, or about one four-hundreth part of the whole sewage, or nearly the same quantity as was applied at the Barking farm.

In the direct application of the sewage to the experimental crops, the liquid was carried around the field by means of channels measuring about 16 in. in breadth, and from 4 in. to 8 in. in depth, and forming a continuous line of more than 1,000 yards in length. The ground was divided into beds, or furrows, varying from 24 in. to 40 in. in width, and the trenches between the beds varied from 6 in. to 12 in. in depth, and from 20 m. to 25 m. in length. The sewage was by this means carried to the roots of the plants, and never approached their leaves. In the winter, when the ground was cleared, it was prepared in the following manner: The surface was roughly levelled, and the sewage directed over the surface of the ground, which absorbed the liquid, while the matter in suspension formed a deposit upon the surface.

The alum preferred for the operation of purification was obtained by treating kaolin with sulphuric acid, delivered in the form of a solution, having a density of 1.074. Its composition is stated as follows: Alumina, 2 per cent.; sulphuric acid, 5.40 per cent.; iron, a trace; water, 92.60; and its cost, just one shilling per cwt. The quantity employed was rather less than one-half litre per ton of sewage to be purified, and the cost little more than one-tenth of a penny. Many other purifying agents have been tried at the works, but none have been found to possess the necessary qualities, combined with cheapness, to the same extent as the

sulphate of alumina. The purification pits are thirty metres long by two metres in depth, with sloping sides, giving an average width of eight metres. Each of these purifiers is capable of yielding from fifty to sixty tons per hour, with an expenditure of ten kilogrammes of the solution. Practically it appears, according to the report, that each ton of precipitate, in a perfectly dry state, requires an expenditure of 7s. 6d. for alum.

The effects of the sewage water as applied to grass, vegetables, and flowers, are carefully tabulated, and place its value as a manure beyond doubt. This, however, is no new result, and our space will not allow of our giving unnecessary details. Some special experiments, however, have considerable importance; for instance, one-half of a piece of grass was cultivated with the aid of purified sewage only, that is to say, the water from which the precipitate had been obtained by means of alum; while the other received in addition a dressing of the precipitate, about an inch in thickness, while another piece by its side was treated with a thin dressing of the precipitate and without any sewage or other water. The former yielded a crop equal to $37\frac{3}{4}$ tons per hectare, and the un-irrigated part only produced at the rate of $4\frac{1}{2}$ tons, while the soil in the former case was found on analysis to be considerably richer than it was previous to the experiment. The soil, it should be mentioned, was a poor virgin subsoil, wanting in nitrogeneous and phosphoric elements. In another instance two equal portions, each of 715 square metres, of a patch of wheat, were cultivated—one with two-and-a-half tons of common manure, the other with the same weight of the precipitated matter of the sewer water; the produce in grain was the same in each case, namely, thirty hectolitres, and of precisely the same value; but the value of the straw was rather more on the side of the farm manure, namely, 281 f. against 225 f. This experiment is being repeated this year in order to ascertain whether there is any difference in the condition of the soil in the two cases.

With respect to the success obtained in these experimental essays, we have a report of a commission composed of the president and many of the most active members of the Imperial Society of Horticulture, of France. The commission pronounces the experiments completely successful, especially in the case of cardoons, salad, including endive, pumpkins, melons, beetroot, maize, and potatoes.

The experiments at Clichy have now come to a close, but pipes have been laid down to carry the sewage across the river, where a large tract of ground on the plain of Gennevilliers will allow of the essays being continued on a broader scale. Some few of the experiments referred to above, were tried by farmers and others on their own grounds to aid the commission, and similar assistance is being given by farmers and market gardeners this year.

In their *resumé*, the reporters say: "These 190,000 tons—which are thrown into the Seine every twenty-four hours, and which will presently be increased—can they be turned from the river? Can they be utilized? Yes, by adopting the natural means of irrigation; and, during the dead season, by purification by means of alum. The result, which will be obtained without danger to health, will be to convert into market gardens the sandy plains around Paris, which are now occupied by grain crops. The cost—which must be set down at two to three centimes per ton for distribution and purification together—will be a heavy one for the city, if left to bear it alone. It is for the cultivators to understand that they can afford to pay for sewage, precipitate, and purified water. It is necessary, therefore, to create customers. Before going further, the municipal authorities have directed that the attempt should be made, and this is the object which we now have in view."

The scientific and at the same time practical manner in which the experimental work has been carried on, reflects the highest credit upon the engineers to whom it has been intrusted. They have fully succeeded in showing the utility and economy of the direct application of sewage; they have adopted perhaps the best agent of purification in an economical sense, they have shown the great value of the precipitate as a manure, and the lesser value of the purified water; but they have not yet, unfortunately, shown that purification can be made a paying process, and the general opinion is that customers will not be found to pay for the product a sum equal to the cost of the operation. But it must be remembered that these experi-

ments refer to sewage much less rich than that of London. The following is the amount of foreign matter found in a ton of the water of the Paris sewers: Nitrogen, 0.037 kilos.; phosphoric acid, 0.015 kilos.; potash, 0.030 kilos.; soda, 0.101 kilos.; organic matter, 0.729 kilos.; mineral matter, 1.802; total kilos., 2.804, or nearly 6 lbs., of which only one-third consists of fertilizing elements. If our neighbors can find a paying market for the precipitated matter from such sewage, they will have performed one of the most useful victories which practical science has yet achieved, and we heartily wish them success.

LA CIOTAT.

From "The Railway News."

Creusot is not the only great manufacturing establishment in France which exhibits manufacturing skill of the highest order, and which also has thought fit to provide systematic training for the skilled workmen who give to the works they exhibit the scientific perfection and high finish which have astonished the English jurors and taken by surprise the large mass of the British public, who had hitherto believed in our own unapproachable supremacy in the highest branches of skilled manufacture. There is another manufacturing establishment besides Creusot which exhibits large marine engines and models of steamships. La Ciotat is a small town in the south of France, containing 10,000 inhabitants, who are almost all families of workmen employed in the shipbuilding yard and the engineering establishment of the company called Les Messageries Imperiales. What this company does, what it exhibits, and what teaching it provides for its people, is in many ways worthy of our consideration.

This company is the proprietor of a large fleet of Mediterranean steamships. Much of the Mediterranean steam trade that used to be carried on in English steamships with English engines is now done with French engines and French steamships built at La Ciotat. It is not more than fifteen years since that company obtained possession of La Ciotat, and made contracts for the French Government in the Mediterranean, and it has now succeeded in driving most of the English ships, engines, and companies who used them, out of the coasting trade of the Mediterranean. Of these ships and engines there are some excellent models in the marine department of the French Exhibition; they are obviously the work of high education and perfect organization. Perhaps, however, we may accept the fact of La Ciotat's having driven us out of so large a field of profitable enterprise, as the highest testimony that can be borne to the excellence of the administration there.

But the company has done another thing still more worthy of notice, especially as it comes still closer home to us. This company is the great rival to our own great steam navigation company, the Peninsular and Oriental. A few years ago the Messageries Imperiales established a rival line of mail steamers, to carry European mails by Marseilles, Alexandria, Suez, and the Red Sea, to India and China. We at first disregarded, perhaps despised, this daring attempt to place steamships and engines of French manufacture on a large oceanic line which we had always deemed exclusively our own. But it turned out that the French company had so well thought out their plans, so well proportioned their ships and engines to the work to be done, and so finely organized their executive, that from the moment they started till now their line has been distinguished above ours by greater punctuality and fewer accidents; indeed, the work is done so well that in our own Parliament last session the representative of the Treasury told the House of Commons that England would best consult the interest of its territories in the East by confiding part of our mail service to the company of La Ciotat, instead of trusting them exclusively to the ships of our own Peninsular and Oriental Company.

The details of the education which this company provides for its people are remarkable. Its chief superintendents are engineers and naval architects who have received the highest professional education that France provides. Its ships are

designed by men who have first passed through the Ecole Polytechnique, and afterwards graduated at the Imperial School of Naval Architecture. Its chief engineers have in like manner graduated in science at the Ecole Polytechnique, and completed their studies in the school of marine engineering, or are pupils of the central school of manufactures at Paris. The next class under these have also been educated at the central school of arts and manufactures. It is no wonder, that with such men as these at the head of the workshops, the want of educated workmen should speedily have been felt. The company employs 2,500 workmen and apprentices, who, with their families, form a population of 6,000 out of the 10,000 inhabitants of the town; and they provide wholly, or contribute largely to, the funds for the schools for the education of these people.

There are, first, the infant schools, which contain 260 children, under the superintendence of nuns, who give them religious instruction and teach them elementary grammar, reading, arithmetic, and geography, and to the girls sewing and other kinds of woman's work. The next schools provided are the elementary schools, which contain 350 boys; they remain until the age of 13 and 14, and receive the ordinary elements of a boy's education. At the age of 14 their technical education and the special duties of the company commence. An apprenticeship in the works of La Ciotat is from beginning to end a course of technical instruction. The superintendents remark with pride that all the foremen and workmen delight in teaching the youth. The company has done away with the system of obligatory apprenticeships for a fixed period. The children not only receive wages from the moment they enter the establishment, but those wages are increased as soon as greater knowledge and skill enable them to do better work.

But their apprenticeship is not merely a school for mechanical dexterity. The company has a school-room, in which all the apprentices are educated gratuitously during one hour of the day, and that hour counts as one of the 10 hours of their day's work. Attendance at this school is compulsory on all the apprentices; but they have in addition an evening school, which those may attend who will. Three evenings a week plan-drawing, designing of machinery, designs of ships, and ornamental drawing are taught gratuitously. Two hundred apprentices and workmen regularly attend this class. The superintendents say that they do not know which to admire most, "the anxiety of workmen and apprentices to obtain admission to this course, the diligence with which they apply themselves to its work, or the order and silence which pervade the school-room." This is really the highest sort of technical education; and there is a strong inducement to take advantage of it in the circumstance that the company selects men for the responsible duty of engineers of steamships from those who have distinguished themselves in this course, and take the highest places in an annual examination at which gold and silver medals are distributed as prizes. The company also provides a library, which is open to their people from eight till ten in the evening and ten till four on Sundays. The formation of bands of music is encouraged. Workmen's houses have been erected, with all modern appliances for pure air, cleanliness, and domestic economy; there are gardens attached to each; each contains a kitchen, a large room with two windows and an alcove, and another chamber with one window; and they are let to the workmen at from 65 to 100 francs a year. With a further view to economy, the company has also organized a market for butcher's meats. It has founded hospitals and savings banks, provided funds for sickness and death, and pays members of the religious orders to attend to the moral and religious education of the people.

Such is the moral and intellectual apparatus provided by this mercantile company for training its workpeople. The next point is, whether all this training really produces the improvement aimed at. We have an official judgment on this subject: "The commissary of police, the justice of peace, the gendarmerie, and the public prosecutor, all state that they are surprised at the small number of misdemeanors and crimes to be met with in the population of La Ciotat." Three facts are adduced as a proof of the high moral tone of the workmen. 1. In 1858, there was an almost total cessation of work in the establishment. Instead of dismissing men, the company decided to employ and pay them only a third of each day, and

the workmen accepted the sacrifice without a murmur. 2. In 1851 the mechanics of Marseilles struck for higher wages, and sent their emissaries to La Ciotat in order to obtain their co-operation; the attempt utterly failed. 3. Those apprentices who have been some time in school differ from those who have just entered, not merely in intelligence and age, but in a higher moral tone and conduct, the result of their education. In a money point of view, the managers say that the company reaps an ample reward in the superior intelligence and steady conduct of their workmen.

MINING EXPERIMENTS.

From "The Army and Navy Gazette."

The approaching completion of the lines of defence at Hilsea, which are intended to cover the only approach to the Island of Portsea from the mainland, has necessitated the demolition of that portion of the lines of defence which cover the towns of Portsmouth and Portsea. In carrying out this work, advantage has been taken of the opportunity for making some mining experiments on a comparatively large scale, which have proved exceedingly interesting to the scientific branches of the service. Under the directions of a committee of Royal Engineer and Artillery officers, accompanied by Mr. Abel, the chymist to the War Department, comparative experiments have been made between the powers of gunpowder and gun-cotton to destroy the walls of the fortifications. The mines in the stone escarp and counterscarp walls have been constructed, charged, and fired by the officers and men of the Royal Engineers stationed at Portsmouth, under the direction of the officers forming the committee and the War Office chymist. The first experiment made was on the right flank of the Portsea line of defence. Four shafts were sunk in rear of the escarp wall of a projecting bastion, two of these being on the front and two on the left face of the bastion. The earth of the rampart, as in all the subsequent experiments, was cut back some fifteen feet from the top of the escarp, so that the weight of the soil on the charge was due solely to the depth at which the mine was fixed behind the escarp. The ordinary service friction battery was used for firing the mines. Three of the four mines behind the two faces of the bastion escarp were loaded with gun-cotton, prepared on a plan recommended by Mr. Abel. The three charges were respectively of 46, 36, and 30 pounds. The fourth charge was composed of 70 pounds of gunpowder. When the explosions took place there was a vast trembling of the bastion at the moment of the explosion, with an upheaval of the escarp and the base of the rampart at its back, great sheets of flame playing strangely over the cotton mines, and four great gaps in the escarp where the mines had been placed, each forming a crater spreading out into the ditch beyond the wall, and filled with stone, changed from square blocks into millions of shapeless splinters. A storming party, six abreast, could have charged through each breach ; and what remained standing of the escarp was disintegrated throughout in structure, and ready to fall into the ditch on such slight impulse being given to it as the blow from a round shot of the smallest calibre. The next experiment in such blasting was made on the counterscarp wall of the Lion Ravelin, in about the centre of the same line of works. Here eight holes had been driven with bits at the back of the wall at short distances apart. Four on the right of the wall revetements were each of 3½ in. in diameter and 6 ft. in depth. They were loaded each with 6 lbs. of gunpowder and then tamped in with earth. The other four, on the same face of the counterscarp and adjoining, were each 3 in. in diameter, and were charged with 3.5 lbs. of the pulp disc-formed—or, to speak more correctly, cylinder-formed—gun-cotton. In this latter instance, however, the holes, owing to the obstructions met with in driving the bits, were sunk "out of line," and, as a consequence, the cylinders of cotton could not be packed in them with sufficient closeness to insure results of any value ; and, in addition to this fault, the holes were very wet, so that altogether but little was expected from them, and the truth of this anticipation was soon confirmed. The four holes charged with gun-

powder were connected and fired from the friction battery with good effect. The whole of the counterscarp for 16 paces was thrown into the ditch, and some of the large stones projected as far as the water channel in the centre. The stones of the counterscarp on either side of the gap were bulged outwards, and entirely disintegrated from each other for about three yards.

The general object of these experiments is not only to test the comparative merits of gun-cotton and gunpowder as the means of demolishing fortifications, but also to find out the best and most portable preparation of gun-cotton which can be used on actual service. Mr. Abel has devoted a great deal of time to this subject, and is now testing the various preparations he has prepared of this explosive. The ultimate results can only be known after the official report has been sent in to headquarters, and as yet the experiments themselves have not been brought to an end. But, so far as the various minings have been tried, it seems that more than one of this gentleman's preparations are highly approved of by the officers who were present. One of these preparations is in compressed discs, the cotton being reduced to a pulp as in the cylinder form, and with this two (preliminary) trials were made, which were very interesting, and may bear some discussion on the causes of the results obtained with them. The cotton is compressed in discs of about the diameter of a small tea saucer, and about $\frac{3}{4}$ in. in thickness, weighing each about 7 or 8 ozs. One of these discs was placed on one of the massive coping-stones of an escarp masonry wall and fired by wire connection with the friction battery. The disc exploded with a sharp ringing report equal to that of a shotted 40-pounder Armstrong gun, and the coping-stone, on examination, was found to be shattered, as it lay wedged in its bed between the other stones, into a hundred pieces. The next experiment with these discs was made with 16 of them strung together (in two lengths of 8 in each), and hung against the face of a counterscarp masonry wall. If the one disc had done a certain amount of damage to the coping-stone of a counterscarp, what was to be expected from 16 such discs exploded together on the face of the counterscarp? The difference in the two cases was this. The single disc lay with its flat surface resting upon a flat stone. The 16 discs hung against the face of the stones, and not upon them, and the edges of the discs—not the flat surfaces of the latter—only touched the wall. When the hung discs were fired they emitted a blinding sheet of light, and sent out a hard ringing detonation, equal to that of the heaviest ordnance, but clearer and more metallic than the voice of any gun ever yet fired. The result was somewhat astonishing. The 16 discs had done less execution than the one. Where they had hung against the wall the stone had "scaled" off to the depth of two inches, and this, with the exception of a little shaking at the joints, was all. The intention in both instances was to deliver a blow, steam-hammer fashion, on a stone-fronted work that should make a sufficient hole in the face of the work for a man to rush up to, under cover of rifle fire, and deposit a second charge, the end being, of course, that a sufficient charge should be at length exploded in the hole thus made, to bring down the wall and make a breach to the attacking party.

New Mode of Setting Boilers.—Several boilers in Sheffield have been set upon a new plan. By a simple arrangement of fire-clay plates, says the "Sheffield Independent," so managed as not to contract the capacity of the flue, at any single point, the gases, after being thoroughly intermixed, are at four successive stages in their progress through the flue, thrown, in thin streams, against the surface of the boiler. No part of the gases can escape this repeated forcible contact with the boiler, and in the process the heat they contain is so thoroughly extracted and absorbed that the result obtained, as proved by careful tests, is the evaporation of nearly 12 lbs. of water for every single pound of fuel, common boiler slack being used. This gives a large saving of fuel as compared with the best modes of setting previously in use. The patentees, we understand, guarantee a saving of 25 per cent. The apparatus has the additional advantage of being an effective smoke-consumer. The plan is applicable to any class of boiler; can be applied without unsealing boilers already fixed; and the plates being of fire-clay, the cost is so moderate as to be very soon repayed by the saving of fuel.—*Builder.*

FURNACE BOILERS.

From "The Engineer."

The jury empanelled to hold an inquest on the eight men killed by the explosion at the Britannia Ironworks, Bradley, have returned a verdict over which all sensible men will rejoice. They found that the deceased persons lost their lives by the explosion of an old and much worn steam boiler, and, in addendum, they expressed a hope that what had been disclosed at the inquest might be a warning to the owners of boilers, and to persons whose special duty it is to look after and examine such machinery. The jury stated that if it had appeared to them in evidence that notice of the dangerous state of the boiler had been given to any person whose duty it was to attend to it—whether master, owner, or servant—and that such notice had been neglected, and that death had ensued in consequence, they would have returned a criminal verdict against the persons who had neglected so important a duty. This verdict strengthens the hope that the day is not distant when juies called in to determine how men come to their deaths in our ironworks and our factories, will return verdicts in accordance with the evidence, and with common sense.

In another place we have spoken fully and freely on the evils attending on the existing system of repairing boilers, and it is not our purpose here to dwell at length on that subject. The failure of the Bradley boiler, however, points a moral which it is as well we should draw; and gives force to the statement that boiler engineering, as exemplified by ironworks practice, is of very nearly the worst possible kind. Not only do explosions occur with alarming frequency in our iron districts, but they are attended by a loss of life without parallel. Such effects can only follow on well-known causes. The facts tell us as plainly as possible that furnace boilers are overworked, badly made, inefficiently attended to, and improperly located. This testimony of facts has never, so far as we know, been disputed; yet we are at a loss to find any evidence of a general desire on the part of those engineers who design ironworks to adopt a better practice. In a few isolated instances, indeed, the case is different; but such displays of forethought and skill, only make the general practice of furnace boiler engineering appear in a still worse light. A very few years since, it was considered by many eminent iron manufacturers, that no saving in fuel was to be expected from the use of the waste heat of puddling and reheating furnaces in raising steam. This was a fallacy, and a reaction set in, which resulted in the belief that any amount of steam could be had from the waste heat of furnaces, and that it was quite unnecessary to be particular as to the form of boiler used to raise steam, or as to the qualities of the engines employed to utilize it. This is, if possible, a worse mistake than the first; it is certainly a fatal mistake in some respects, whereas the first was only an economical mistake. That steam enough can be raised from the waste heat in an ironworks, to do all the rolling and forging necessary, without the aid of hand-fired boilers, is certain; but it is not less certain that to attain this desirable end the boilers must be properly designed, and the engines so constructed that they will be at least fairly economical. The waste heat of any average ironworks is not more than necessary, and if it be improperly used, either hand-fired boilers or an extravagant consumption of fuel will be found absolutely necessary to keep up the proper supply of steam. It is impossible in an article like the present, to discuss all the questions that will suggest themselves to the engineer-manager of an ironworks; but we shall call attention to one or two points which greatly influence the yield, estimated in terms of power, to be had from waste heat.

The first thing to be done is to see that the machinery driven runs as lightly as possible. In how many mills do we find the smallest attention paid to this point? We see rolls out of line, standards loose and askew in their bed plates, roll necks turned oval or eccentrically to the roll bodies, coupling boxes and spindles put together "anyhow;" gearing—well, the less we say about rolling mill gearing, especially in old mills, the better. A maximum of metal is intended to compensate for the absence of good design, fair proportions, and accurate workmanship. We venture to assert that 50 per

cent. of the power required in most rolling mills is expended in driving the machinery, and we challenge the old school of ironworkers' engineers to dispute the statement. Here, then, is one source of waste; enormous quantities of steam are required to overcome a resistance which should not exist, and the boilers are expected to compensate for all deficiencies. It is astonishing what a difference there is between a well set up mill and one out of line and out of order in the matter of resistance.

If we turn to the engines we find them, as a rule, still worse than the mills; it is impossible to conceive how bad a steam engine can be without going into our iron making districts. Anything that will turn a wheel round will do. The piston and valves may be leaky, the bearings all pounding and banging, the shafts out of truth, the guide-blocks thumping up and down in the slide bars, or the parallel motion all wrong; the foundations loose, the cylinders and steampipes unlagged; the joints all blowing; still the excuse is, "She will drive the mill if there is only steam enough behind her, and it costs nothing to get steam because of the waste heat." In practice we find, as a result, that much more steam is got out of the boilers than there is any need for, and that fuel is wasted by working furnaces harder than they need be worked; but even this will not suffice. A case came under our notice the other day in which a firm was compelled to keep on making puddled bars for sale for which they had no need, and by which they lost over £800 a year, in order to keep steam to drive a mill working on finished iron. No fewer than 16 furnaces, burning 320 tons of coal per week, were employed to get at most 300-horse power. This is, perhaps, an exceptional case, but it is not very exceptional. We know, for example, that another firm in the north pay £3,000 a year for fuel in hand-fired boilers alone, required to supply steam in addition to the furnace boilers. Now, our experience goes to prove that any one furnace will, on the average, where plenty of furnaces are employed, supply steam enough to roll all the iron it can heat into bars or sheets. The same will hold good of puddling furnaces as regards the conversion of the puddled balls into puddled bars, and it follows, therefore, that the waste heat in any ironworks of moderate dimensions is sufficient, if properly used, to find power for that works, so that hand-firing boilers are totally unnecessary.

In order to secure this end, however, the mills must run with a minimum of frictional resistance. The steam pipes must be clothed, and the engines must work to a considerable extent expansively. These things in themselves will accomplish a great deal, but the very essence of success lies in the construction and arrangement of the boilers and furnaces. The first should be so arranged, and of such dimensions, that they may take up all the heat except that required to secure a good draught, which is to be promoted by the use of high chimneys; and the furnaces should be so disposed that the smallest possible distance may intervene between the furnace throat and the boiler. It is commonly assumed that the heat will be too intense, and will injure the boiler if the furnace neck is short; and this is perfectly true, if, firstly, the flame is allowed to impinge directly on the boiler plate; or if, secondly, it is shut up closely in the small cylindrical flue of a Cornish boiler. We have seen scores of such boilers, the flues of which were traversed by a perfect hurricane of flame, yet not making very much steam after all, because much of the tube had to be lined with brick to protect the plates. By allowing the flame to spend itself in a large space, the brick walls of which become red or white hot, and radiate heat to the boiler, all risk of injury may be avoided and plenty of steam made; while it is certain that a very moderate increase in the distance intervening between a furnace throat and a boiler will very greatly reduce the steam-producing powers of the latter, especially with some kinds of coal.

The prominent defects of the ordinary vertical furnace boiler are, that it is enormously too large in diameter, and that all the heating surfaces, or nearly all, are vertical, and, therefore, little more than half as efficient as horizontal surface. In addition, these vertical boilers always stand in the middle of a crowd of workmen who cannot possibly escape if the boiler bursts. The great defect of the double and single-flued Cornish boiler is, that the flame is too concentrated, and that there is nothing like heating surface enough provided unless the boiler is made

of extravagant length. The small quantity of water contained is also an evil. As to what is really the best form of boiler, we shall at present say nothing. That is a branch of our subject to which we shall return. One point is worth notice. In some works all the waste gases from the furnaces are led into a single culvert, and thence taken to a bed of boilers to be employed in raising steam. The gases so taken from a good heating furnace are worthless. All the air required to secure complete combustion has already been admitted through the bars, and nothing will escape from the furnace that will not be consumed within a couple of yards of the furnace neck. It is really the waste *heat*, not the waste gases, of such furnaces that must be utilized in raising steam. The case is different with puddling furnaces, because in certain stages of the puddling process air is not freely admitted, and the products of combustion can be led to a distance and consumed as though they came from a blast furnace.

But prominent above all other considerations is that of securing perfect safety to the hands employed. Furnace boilers are above and beyond all other boilers dangerous. They are exposed to a temperature higher than other boilers, but excessively and rapidly variable. The water with which they are fed is often bad; they are exposed, in a word, to abnormal and potent deteriorating agencies. In our ironworks, beyond all other places, is inspection required; and, glancing over the fearful record of boiler explosions in ironworks which have occurred within the last few years, we feel almost disposed to endorse the wishes of the Bradley jury, and to hope that Parliament would undertake the inspection of steam boilers generally, by the appointment of proper officers. We cannot go quite so far as this, however; but we do trust that such a measure may be passed during the next session as will insure the proper examination of all steam boilers, though not necessarily by Government inspectors. Such an act has become absolutely necessary. If it is not asked for and obtained by users of steam power, others will insist on the passage of a very different law, infinitely more troublesome and arbitrary in its character.

A SHORT HISTORICAL SKETCH OF METALLIC ZINC.

From "The Mining Journal."

If we may depend on the traditions and records of the Chinese, we learn that they were acquainted with metallic zinc at a very early period, and we must ascribe the first discovery of the metal, like that of so many other concomitants of our modern European civilization, to the inhabitants of the East. The fact is, that the metal was imported from India by the Portuguese, in the seventeenth century, under the name of spianter, or spialter, before its nature was recognized in Europe. Whether the ancient civilized nations of the West were acquainted with metallic zinc cannot be ascertained, but there is a great probability that they were. The high degree of development of some of the ancient nations on the shores of the Mediterranean, with regard to metallurgical operations, their very extensive manufacture and use of brass, make it most likely that they knew also metallic zinc, and some way of extracting it from its ores. It is true that the writings of the old Greek and Roman authors do not refer to it; it appears, on the contrary, that they regard brass and yellow metal as only a colored copper, and the Greek word "chalkos," as well as the Latin word "aer," meant both copper and brass, though some authors, as Strabo and others, used sometimes the word "aurichalcum" for the latter. This, however, only related to the color, and meant nothing but a gold-like copper. If we consider the difficulty of communication, the continual and violent political revolutions in the ancient world, the absence of all the present facilities for spreading and preserving any knowledge—further, the fact that our historical sources consist chiefly of the fragmentary writings of a few philosophical scholars, we may easily conceive the possibility that some ancient knowledge may have been entirely lost to us. Our oldest historical documents are the writings of Aristoteles (fourth century B. C.) and Dioskorides (third century

B. C.); they only refer to the manufacture of brass, by admixing an earthy substance ("kadmea") with the copper. The latter author also mentions the application of zinciferous deposits from the brass kilns for the same purpose, and distinguishes from it the white oxide or flowers of zinc, under the special name of "pompholix." In his description of the latter substance he compared its appearance to that of wool, which gave rise to the newer alchymical name of "lana philosophica," much used by the authors of the middle ages.

As, in general, the principles of the Alexandrian scholars, and especially those of Dioskorides, were forming the foundation of natural science for a long period, so it was also the case with regard to their views on brass, and the other zinciferous substances. The following Roman authors—Pliny, sen. (first century A. D.), Strabo (first century A. D.), and Festus (fourth century A. D.), who left us some treatises on natural history—adhered to those principles, and throughout the whole middle ages, down to the latest time, we find them prevailing; the only thing worthy of remark for our purpose during that period is the origin of some words relating to zinc.

From the fifth century A. D., we find the name "jutia" employed instead of "kadmea" or "cadmia," as well for calamine as for the zinciferous furnace deposits. Zosimus in the fifth, Geber in the eighth, and Avicenna in the eleventh century, make use of it in their treatises on brass smelting. Some Arabian authors, also, employed the word "clymia," or "calimia," synonymously with "jutia," from which words subsequently calamine or "lapis calaminaris" was derived. The latter word appears first in the writings of Albertus Magnus, in the thirteenth century. He made a distinction between "calaminaris" and "jutia," applying the former word to the natural mineral, and the latter to the zinciferous furnace deposits, and considers them both equally applicable to brass making. The word "zinc" or "zinken" is of later origin. We find it employed, first, in the fifteenth century by Basilius Valentinus, without, however, any clear definition accompanying it, which even leaves it uncertain whether he meant a metal by it or some other zinciferous substance. The first who described metallic zinc by that name, and undoubtedly in accordance with some of its real properties, was Paracelsius (sixteenth century), although it would appear that his notion did not generally prevail, for down to the end of the seventeenth century a general confusion existed about the use of the word. Some authors employed it for the zinciferous furnace deposits, some for bismuth, cobalt, and other metals. It was only at the commencement of the eighteenth century that the ideas on the nature of brass and zinc became clearer. Kunkel announced in the year 1700, and Stahl conclusively in 1718, that calamine required to be reduced to zinc before it would combine with copper during the brass smelting process. The notion prevailed, however, for some years afterwards that a reduction of calamine into metal was only practicable when copper was present, until Schwab in 1742, and Markgraf in 1746, published some methods of zinc distillation by means of fire-standing retorts.

From this time we meet also with credible records of practical enterprises for carrying out the distillation of zinc on a large scale. For many centuries three districts in Europe were chiefly noted for producing zinc ores—some parts of the South of England, the neighborhood of Aix-la-Chapelle, near the Rhine, and the environs of Beuthen, in Upper Silesia. It is certain that the calamine mines of Altenberg, near Aix-la-Chapelle, have been worked from about the year 1430. In 1565 the first concession was granted for starting a calamine mine, near Beuthen in Silesia, where many mines were soon after opened, of which the Scharley-grube was, and is still, the richest. At all these places the ore formed an important article of trade, and was sent (especially from Aix and Beuthen) to the various distant brass works. It is obvious that from these places the first efforts proceeded for extracting metallic zinc on a large scale, and in England, Dr. Isaac Lawson seems to have been the first who succeeded in introducing a practical method for that purpose; certain it is that in the year 1758, a patent was granted in the name of Champion for a method of extracting zinc from blende, called at that time "black jack," "mock jack," or "bragill." The first works were erected in the neighborhood of Bristol, and were described by Watson, who visited them in

1766. According to his reports, their method was very similar to that in use in England to so recent a period as 20 years ago; it was a "distillatio per descensum," and forms the basis of the old English system for reducing zinc. In this process the distillation took place in closed crucibles; the volatilized zinc was made to pass through an orifice at the bottom of the crucibles into a vertical iron tube, where the vapors of the metal were condensed, and dropped into a vessel containing water standing beneath it. The furnaces used were either rectangular or round, with a fire-place in the middle, surrounded by the crucibles. This method was the only successful one employed throughout Europe for even about 50 years, and it attained considerable development, so that it competed for even 20 or 30 years longer with the newer methods, which are generally adopted under the name of the Belgian and Silesian systems, and which are more open to modifications and improvements. Both these systems originated about the beginning of the present century, when almost contemporaneously (in the years 1808 and 1809) patents were taken out by the Abbot Donny at Liege, and J. Chevalier Ruberg at Wessola, in Silesia, for new methods of reducing zinc.

The principal difference between the three methods mentioned lies in the form of the clay vessels or retorts introduced for the reduction and distillation of the metal. In the English process that vessel consisted of a large crucible, in the Belgian it represents a cylinder, and in the Silesian process a somewhat oblong, flat-sided tube, termed muffle. It is hardly necessary to say that this difference in the shape of the retorts arose originally from the way which the inventors found to succeed best in their first trials to extract the metal. Ruberg, for instance, performed his first experiments by means of a common assaying muffle, as used for cupellation. These muffles are generally of a semicircular front, and so we find them also employed for the zinc smelting process in Silesia to about the year 1835, only of larger size. The peculiar shape of the retorts influenced the arrangement of the furnaces of the different systems. Of the Belgian tubular retorts several horizontal rows could be placed in one furnace, forming an arched chamber with a fire-place beneath, whilst the flat-bottomed muffles only allowed of the arrangement of a single horizontal row along both sides of a fire-place, covered over by a flat arched vault. By such a disposition it was practicable, both in the Belgian method as well as in the Silesian method, to fix the condensing apparatus entirely outside the furnace, convenient to the workman, and facilitating as much as possible the operations of charging and discharging the retorts. This is one of the great advantages which the two newer systems exhibit in comparison with the old English one. Another is in the practicability of enlarging the furnaces, the original size of which was undoubtedly small. Even the first improvements were not as much directed towards the enlargement of the furnaces as towards that of the retorts. In the first place, the necessary temperature for the reduction of the zinc ores, and especially the great advantage of a swift process, were underestimated. Most of the Silesian zinc works, to the year 1835, employed muffles of 18 in. width inside, which of course only required to be charged once every two or three days, without even then allowing of a complete exhaustion of their charges. Similar anomalies we meet with also in the Belgian system. The size of the retorts forms, no doubt, one of the most important elements in the zinc smelting process, and the development of our two present methods is chiefly due to the recognition of this fact.

It has been mentioned already that in the second half of the last century the first zinc works were commenced in England; so also the discovery of the two methods in Belgium and Silesia was soon followed by the erection of zinc works in those countries. The first one in Belgium was that of St. Leonard, at Liege, and in Silesia, the Lydogniahuette, at Kœnigshuette, both starting about the years 1809 and 1810.

However, the practical application of metallic zinc was still at that time a very limited one. Zinc was regarded as a brittle metal, not suitable to be worked by itself, and though Hobson and Sylvester, at Sheffield, proved by some experiments, in the year 1805, its ductility and fitness for being rolled into sheets, the only application of it was to the manufacture of brass and yellow metal; but even for this purpose the use of calamine was kept up for

some time. No wonder that the demand for spelter, and, consequently, the activity of the smelting works, were very limited. At intervals, under the influence of speculation, the price of the metal advanced sometimes to a considerable extent, but only to decline afterwards. No metal has undergone in modern days such extremes in price as spelter ; frequently we find it varying on the Continent from £10 to £75 per ton within the last fifty years, and it is obvious that such a state of things could not be favorable to the development of the spelter trade in general.

Step by step, however, this unsteadiness ceased with the rapidly spreading recognition of its almost unparalleled advantages for many technical purposes. Great progress was made in this direction by the successful application of the metal to artistic and monumental castings, applied first at the Royal Iron Foundry at Berlin, in the year 1833. Even in the earliest times bronze was proved to be the metallic substance most suitable for such castings, and it will, no doubt, continue so for the classic monumental art. The costliness of bronze, however, limits considerably the common use of it in the ornamental line, and the want of a more generally applicable substitute led long ago to many experiments with cheaper metal, as, for instance, cast-iron, and even lead. The difficulties connected with the casting of large iron statues, and with the chiselling of them afterwards, are great points against the use of this metal, whilst its exceeding softness, ponderosity, and consequent instability, render the latter almost unfit for the purpose. Zinc, on the other hand, offers, by its natural properties, and its comparatively low price, every qualification for it. The only difficulty in its employment lay in the method of casting. Experience showed that full round castings of zinc would not succeed by means of the traditional closed loam moulds, and it is the merit of the above-mentioned foundry to have introduced a new method which offers many considerable advantages over the old one. The principle of this new method lies in the casting of zinc in different parts in open sand-moulds, and in joining such parts afterwards by soldering. This process has now been brought to extraordinary perfection, and, united with some modes of pressing sheet-zinc into ornamental articles, and of producing small hollow castings by means of cast-iron moulds, forms the principal industry of large establishments.

Great progress in the application of zinc was also made by substituting it for tin as a protecting coat for iron articles, chiefly for iron sheets for roofing, etc. The first patent for coating iron with zinc was granted to Mr. H. W. Crawfurd in 1837. His process, described in the "Repertory of Patent Inventions," is almost similar to that still in use at our present galvanizing works. It consisted briefly in cleaning the iron objects by immersion in a bath of water, acidulated with sulphuric acid, scouring and washing them afterwards, and dipping them into melted zinc, covered with a layer of sal-ammoniac. They were then slowly removed, to allow the superfluous zinc to drain off, and thrown, whilst hot, into cold water. Iron treated in this way shows a great resistance to the destructive influence of the atmosphere, and the application of this process, therefore, came soon into general use. We may estimate the quantity of spelter now consumed in Europe for zincking or galvanizing purposes to be above 10,000 tons per annum. The above-named properties of zinc rendered it one of the most useful metals; and, moreover, if we add to this its high importance for the electric telegraph, and its enormous consumption in the form of sheets, as well as oxide, we can readily account for the present great development of the spelter trade. It is impossible to name all the purposes for which zinc sheets have been introduced, with almost unparalled success during the last 30 years, and the number is still evidently increasing. It will, probably, be the subject of an extra paper to go more extensively into this matter, in connection with the rolling process, and the manufacture of zinc oxide.

With the beginning of the fourth decenary of our present century we find metallic zinc to have gained ground so far in manufacture and art, that it appeared quite indispensable to them. In the chief calamine districts of Europe large companies were formed for extracting and working the metal, and, though some great fluctuations in the zinc market were experienced, as, for instance, in the years 1848 and 1849, when the price of zinc in

Breslau (capital of Silesia) declined to an average of only £11 5s. per ton, yet a rapidly increased demand, and a proportionate production, always followed. The average price of spelter has been for the last 20 years about £20 per ton; the maximum price during this period was that of the year 1857, when it averaged £27 6s. per ton, and the minimum that of 1861, with an average of £15 7s. 3d. per ton at Breslau.

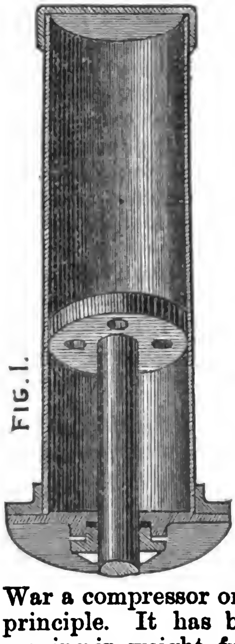
The yearly production of spelter in Europe amounts now to 100,000 tons at least, of which quantity about 50,000 are made in North Germany, 35,000 tons in Belgium, and 15,000 tons in England. The largest establishments for smelting and manufacturing the metal are those of the Vieille Montagne Company, in Belgium; the Schlesische Actiengesellschaft, in Silesia; and the works of Messrs. Vivian and Sons, in England. The metal has attained an importance through the whole civilized world, which places it amongst the most valuable treasures of national wealth in several countries, and ranges it by its applicability and cheapness next to iron amongst our most useful metals. Large quantities are annually exported to the remotest places of the globe, and it is curious, and no less satisfactory, to note the alteration in the direction of the spelter trade. Two hundred years ago we find the metal was exported from India to Europe; now large shipments of it (by far larger quantities than we ever received) are being made from Europe to Asia.

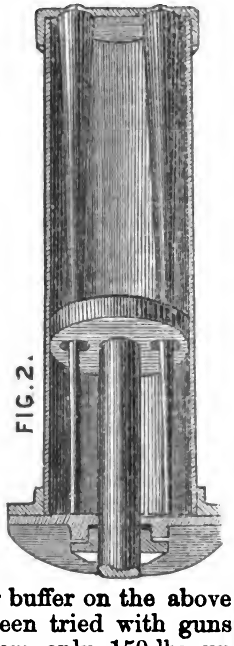
DESCRIPTION OF THE HYDRAULIC BUFFER.

By COLONEL H. CLERK, R.A., F.R.S.

From "The Engineer."

In consequence of a suggestion made to me in October, 1867, by C. W. Siemans, Esq., C.E., F.R.S., to try the effect of water to check the recoil of heavy guns, I submitted to the Secretary of State for





War a compressor or buffer on the above principle. It has been tried with guns varying in weight from only 150 lbs. up to 25 tons, and in all cases the results have been most satisfactory. The amount of recoil can be regulated to a great nicety, and the motion is smooth and regular.

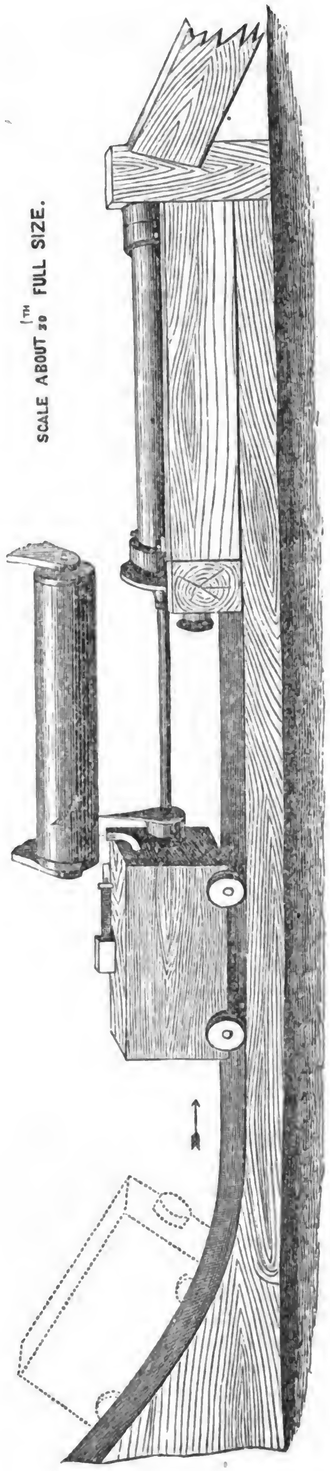
It consists of a wrought-iron cylinder closed at one end, the other end fitted with a cap and stuffing-box, through which a piston-rod passes. The length of the cylinder and piston-rod are regulated by the amount of recoil required, or the space within which it is necessary to bring the moving body to rest. The piston fits well into the cylinder, and is perforated with four small holes. The ratio between the diameter of these holes and that of the cylinder is determined by the amount of work required to be performed on the water with which the cylinder is filled, enough air space being left to allow of the displacement of water by the length of the piston-rod due to the recoil. This air space also acts as an elastic buffer, and takes off the violence of the first impact of the piston on the water. The cylinder is firmly attached to the platform on which the carriage recoils, and the end of the piston-rod to the carriage itself; so that on the discharge of the gun the carriage drives the piston through the water with an initial velocity V, whilst the water has to pass through the holes with an initial velocity R V, R being the ratio between the

area of the cylinder and of the holes. This buffer has not only been used on shore with guns up to 25 tons weight, but also at sea, with light guns of only 1½ cwt. and 8 cwt. in boats, and lately with 9 in. guns of 12 tons on board H.M.S. Prince Albert, in all cases with equal success.

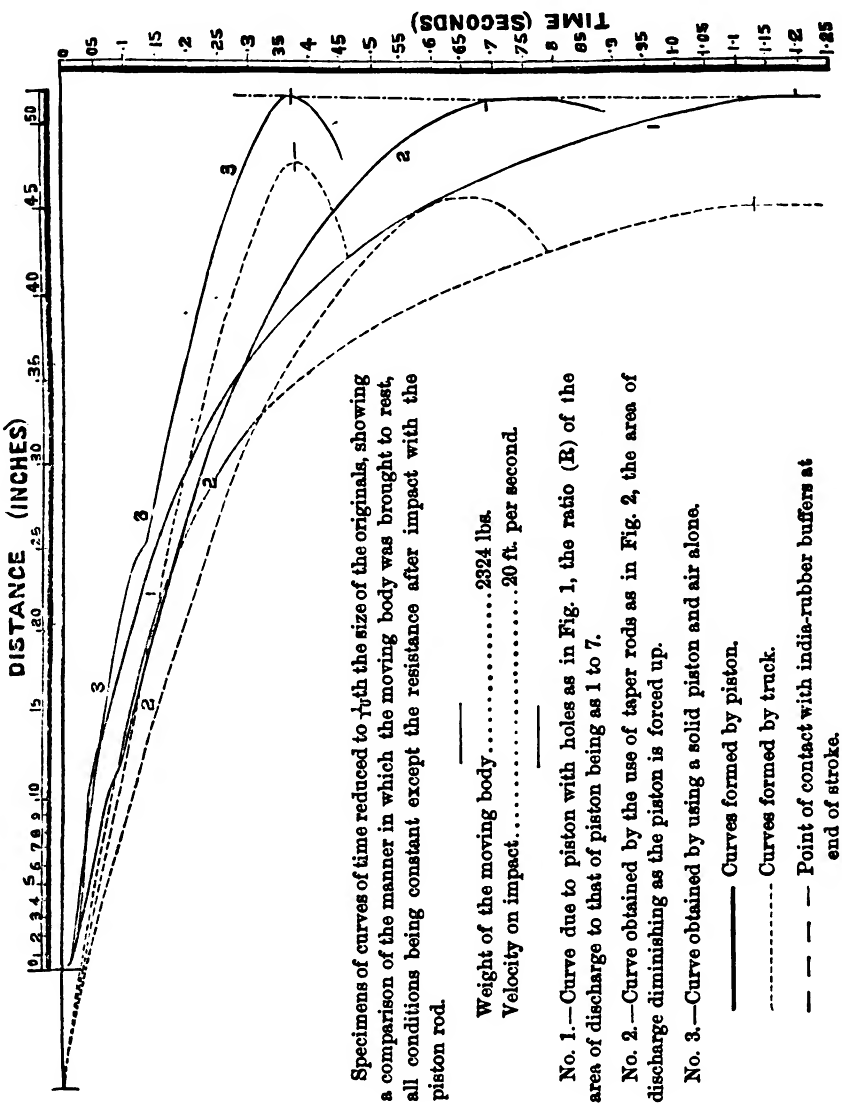
In place of water it has been recommended to use oil, as there is less chance of corrosion taking place if the cylinder is kept full for any lengthened period, and no danger of the fluid freezing in ordinary frosts. The oil used for this purpose is Field's Rangoon oil, which does not become thick except in very cold weather, when Field's non-freezing oil may be used. A small quantity of caustic soda in the water has been found to keep the cylinder perfectly clean and free from rust for many months. The satisfactory manner in which this buffer has worked in checking the recoil of a gun of 25 tons weight leads me to anticipate that it could be most usefully applied towards preventing, or very sensibly diminishing, the destructive effects of a railway collision, for, as by means of this hydraulic buffer a force of impact varying from 1,200 foot-pounds up to 54,000 foot-pounds has been easily overcome in distances from 16 ins. to 60 ins., and on inclinations varying from + 10 degs. to — 4 degs., I see no reason why the principle should not be extended to overcome a force of, say, 1,500,000 foot-pounds in 60 ins.

In checking the recoil of a gun the velocity to be dealt with seldom exceeds 10 ft. or 12 ft. per second, but in the case of a railway collision it is very different; there we have to deal with very high velocities. It is, therefore, necessary to ascertain how the hydraulic buffer will act under these circumstances. For this purpose I have been carrying on a series of experiments at velocities up to 44 ft. per second, or 30 miles an hour, and now forward a short account of them for the information of the members of the British Association.

Two sets of experiments have been made, one with a cylinder 4 ins. in diameter, the other with one 8 ins. diameter. With the former the velocities tried were 10 ft., 15 ft., 20 ft., and 25 ft. per second, with weights of 2,324 lbs., 1,162 lbs., and 581 lbs., and with ratios between the diameter of cylinder and holes in the piston of 15, 21, and 27. With the latter the



SCALE ABOUT $\frac{1}{20}$TH FULL SIZE.



Specimens of curves of time reduced to $\frac{1}{10}$th the size of the originals, showing a comparison of the manner in which the moving body was brought to rest, all conditions being constant except the resistance after impact with the piston rod.

Weight of the moving body..................2324 lbs.
Velocity on impact..........................20 ft. per second.

No. 1.—Curve due to piston with holes as in Fig. 1, the ratio (B) of the area of discharge to that of piston being as 1 to 7.

No. 2.—Curve obtained by the use of taper rods as in Fig. 2, the area of discharge diminishing as the piston is forced up.

No. 3.—Curve obtained by using a solid piston and air alone.

——— Curves formed by piston.

---------- Curves formed by truck.

— — — Point of contact with india-rubber buffers at end of stroke.

velocities were 10 ft., 15 ft., 20 ft., 25 ft., 30 ft., 35 ft., 40 ft., and 44 ft. per second. The weights were 1,162 lbs., 2,324 lbs., and 4,648 lbs.; the ratios 15, 12, 9, 7, and 6. The velocities were obtained by drawing a truck (loaded to the proper weight) up an incline plane of 47 degs. to the proper height, and suddenly releasing it, (a small deduction has to be made for friction). The truck ran down the slope, and striking the end of the piston-rod drove it in, till the resistance of the water overcame all the force of the impact. The cylinder, with piston-rod drawn out, was fixed at the bottom of the incline plane, about two trucks' length from the end of the slope, and was securely bedded in a block of wood propped up behind to prevent its moving. Above the cylinder was fixed a light barrel, 6 ft. in length, made to rotate at the rate of one revolution per second, on which was fixed a sheet of drawing paper; to the end of the piston-rod was fixed a pencil, kept in contact with the rotating barrel by means of a light spiral spring, so that at each collision the piston-rod transferred to the paper a curve showing the time occupied in pass-

ing over every portion of the space through which it was driven. From these curves a series of tables have been formed showing the velocity of the piston-rod for every 2 ins. of the stroke. The diameter of the rotating barrel was 12 ins., so that one second of time was represented by a space of 37.7 ins. Another pencil was attached to the truck in a similar way to the one on the piston-rod; thus two curves were obtained—one of the motion of the piston through the water, the other of the truck when in contact with the piston-rod. A disc of Clarkson's material (a combination of cork and leather) was fixed to the end of the piston-rod, and another to the front of the truck where it came in contact with the piston-rod, in order to deaden the force of the blow. Two discs of india-rubber were fixed to the wood block in which the cylinder was bedded, against which the truck struck in those cases where the force was sufficient to drive the piston right home. The amount that those india-rubber discs were compressed was self-registered, and the value of such compression in foot-pounds having been previously ascertained, we are enabled to estimate the remaining force with which the truck struck the cylinder block at low velocities. By varying the amount of water in the cylinder we could arrange that the truck could just touch two percussion caps fixed on a plate in front of the india-rubber rings without exploding them, the force required to explode a cap being about one foot-pound.

In order to ascertain the effect of the collision on the truck, or rather, what would be the shock a passenger would receive under such circumstances, a weight of about 6 lbs. was attached by a piece of thread (to keep it in its place on the incline) to the end of the truck farthest from the piston-rod. On collision taking place the thread was broken, and the weight driven forward for a space of 12 ins., when it struck against a spiral steel spring, and compressed it according to the force with which it was struck. By means of a pencil attached to the spring, the amount of compression was self-registered, and the value of this compression having, as in the case of the india-rubber rings, being previously ascertained, the force in foot-pounds with which the weight was driven against the spring was obtained. The same relative quantities of water and air were used in all the experiments: In a 4-in. cylinder, water, 380.6 cubic ins.; air, 97.8 cubic ins.; total capacity of cylinder, 478.4 cubic ins.; diameter of piston-rod, 1.5 in. In an 8-in. cylinder, water, 2,794 cubic ins.; air, 424 ins.; total capacity of cylinder, 3,218 cubic ins.; diameter of piston-rod, 2.375 ins. Ratio of thickness of piston to diameter of holes 2¼ to 1.

Different descriptions of fluids, such as oil, glycerine, and methylated spirit, were tried as well as water. Some of the curves thus obtained were exhibited in diagrams at the meeting.

With a perforated piston the resistance of the water is not uniform, being greatest at the commencement, or rather at that point where the air has received its maximum compression. It was therefore considered desirable to try the effect of uniform resistance, and Mr. Butter (Constructor R. C. D.) suggested a very simple mode of doing this. It consisted in fixing along the length of the cylinder four tapering rods, which passed through the holes in the piston; these holes were considerably enlarged, and the smallest ends of the rods being towards the front, there was a large area for the water to pass through in the first instance, gradually diminishing in proportion to the increasing velocity of the piston, thus keeping up an uniform velocity of flow through the holes. Some of the curves obtained with this arrangement, together with section of the buffer, are shown in the diagram above. In order to get the effect of an air-buffer, for the sake of comparison, a solid piston, fitting well in the cylinder, was also tried.

The following is a German recipe for coating wood with a substance as hard as stone: Forty parts of chalk, fifty of resin, and four of linseed oil, melted together; to this should be added one part of oxide of copper, and afterwards one part of sulphuric acid. This last ingredient must be added carefully. The mixture, while hot, is applied with a brush.

The temporary Blackfriars Bridge is rapidly disappearing; the footways are already in great part removed.

ANGLO-FRENCH COMMUNICATION.

By ZERAH COLBURN.

From "Engineering."

From the period of the Roman invasion down to the present day, the English Channel has never been crossed otherwise than upon its own surface—unless the late Mr. Green's aërial voyage be an exception. Neither Julius Cæsar, however, nor William of Normandy lived in a railway age, and but for the miseries of sea-sickness, they doubtless preferred the sail to the best roads of their respective times. But since railways have become the recognized means of communication on land, the question has been pressed, and of late very urgently pressed, whether they may not be also made available for communication—not exactly upon the water, although there is a floating railway across the Upper Rhine—but over or beneath the water, and especially over or under the comparatively narrow and shallow strait which separates our island from the Continent. There are *soi-disant* patriots, it is true, who would on no account witness the loss of our absolutely insular position, patriots to whom England is a castle, and the stormy Channel its moat, and who would not have so much as a drawbridge thrown across that moat, or a hidden way mined beneath it. Such considerations are, however, apart from the present purpose, which is, not to inquire into the international policy or financial expediency of solving this great intercostal problem, whether by a bridge, ferry, or a tunnel, but to examine, very briefly, the engineering and constructive aspects of these proposed works. It is probable that the greater the apparent impracticability of either or all of these schemes, the greater the general interest they attract, and perhaps the same interest may be said to exist also among the members of the engineering profession.

The question of bridging the Channel has been mooted, and at least one scheme has attained some degree of public prominence. The designer's first proposal was to jump the Channel at a single leap; but whether out of his regard, as has been asserted, for the wishes of the Emperor, or from a willingness to conform to certain immutable laws of nature which render such a plan impossible, he subsequently modified his design so as to include ten spans, and it has been since heard that he is willing to extend their number and reduce their width to twenty, of one mile each. Whether even such a superstructure, to say nothing of the piers in a maximum depth of 200 ft. of water, and rising more than 200 ft. above its surface, would or would not be practicable, is a question which may be safely left to those really competent to deal with it, and of these the designer himself can hardly be considered to be one.

Of the entire practicability and great advantage of a Channel ferry there can be no doubt whatever, whether it be established between Dover and Calais, or between Dover and Audrecelles. It is quite practicable to ship and unship passenger and goods trains bodily, and thus to run them through, both ways, between London and Paris. Boats suited for this purpose, and harbors capable of receiving them, could be constructed within a few years at a cost much less than that of any tunnel, whether laid on the bed of the Channel, or carried through the chalk at any depth below it. Such boats would be in as striking contrast to the existing Channel service as that afforded by our finest hotels on the one hand, and the most uncomfortable lodging-houses on the other; or, if another illustration be needed, the most luxurious express saloon carriage and the most cheerless third-class conveyance to be found on any railway in the kingdom. But any boat service whatever, however excellent it may be, has its necessary drawbacks. No ferry boat, even if nearly as large as the Great Eastern itself, could wholly prevent the possibility of sea-sickness, that unspeakable horror of so large a proportion of all landsmen, of whatever nationality. The time occupied in shipping and unshipping trains, however expeditiously the work was performed, would be considerable, and however, high the speed of the boat as a boat, it could not exceed one-half that easily attainable by a railway train. As to the relative safety of a boat service and a train service, it is not now necessary to inquire, although something, if

not, indeed, much, might be urged with reference to collisions in fogs or storms. But the chief objection to boats would be their high cost of working and maintenance. As it would not answer the convenience of the public to detain a boat until two, three, or more trains had arrived at either port, a boat would be required for every train, and its working charges might, therefore, be fairly compared with those of a single train. The consumption of coal alone, with boats of the proposed size and speed, would be from fifteen to twenty times as much as that for the train if run across by itself. The repairs and depreciation of the boats would be very much greater, per pound of their value, than that of the train, and the boats themselves could hardly cost less than £100,000 each, while the train carried, including the cost of engine and tender not carried, would not represent a cost much above £6,000 or £8,000. The wages of captain, engineers, firemen, stewards, porters, and crew, would obviously be far beyond those of the three or four men working the train by itself, and these, and all other working charges, would be divided, mile for mile, upon a very much less number of miles per annum than the number made by the train if run by itself. There would not, of course, be any permanent way charges with which to debit the boat, running on Nature's own highway, but as to capital charges, the interest upon the cost of the harbor works alone would probably be equal to that upon a railway costing £100,000 per mile. It is morally certain that a large Channel ferry, with a full complement of steamers, could be maintained only by a very decided advance in the fares, whether between the opposite coasts alone, or between London and Paris. Assuming that even as many as one hundred passengers were taken across in a single train, the capital charges and working expenses would probably amount to £20 per trip, assuming the boat to make 1,000 trips of 20 miles each per annum, and thus the charge per passenger would be 4s. for 20 miles, or nearly 3d. per mile. The carriage of goods, specie, etc., would lessen this rate, but it is as likely also that the average number of passengers per trip would be very much less than 100. Nor is it at all certain that each boat could make 4 trips daily for 250 days in the year. None of these reasons, however, patent as they are to the observation of all, are conclusive against the Channel ferry. On the contrary, the ferry is the only means of maintaining comparatively expeditious and comfortable communication, of which the absolute practicability is beyond all question, while it could be got to work within probably 2, 3, or at most 4 years, and at a cost, including harbors, of probably little more than £2,500,000.

That branch of the question which possesses real interest—surpassing interest of uncertainty—at least for the engineer, is that relating to a subaqueous way across the bottom of the Channel, or a regularly excavated tunnel 100 yds. or so deeper down in the gray chalk or clay itself. It is, perhaps, the certainty (the question of first cost being for the moment dismissed) that a tunnel, once made, would prove the very best of all means of crossing the Channel, and the qualified uncertainty whether such a tunnel is even practicable at all, that give to the tunnel its great, its even seductive interest to engineers. It need hardly be said that tunnels under water, or rather through the earth beneath the water, are anything but new or unusual. For very many years the tin miners of Botallack, in Cornwall, have driven their headings to a good distance beneath the very bed of the Atlantic itself. Just 60 years ago Trevithick nearly completed a tunnel beneath the Thames between Wapping and Rotherithe, and but for imprudently making a bore hole from the roof through to the river bed, this tunnel would no doubt have been successfully opened. Ralph Dodd had made the same attempt before. Brunel's world-famed tunnel requires no remark, and it will be but a few weeks before Mr. Barlow's tubular subway will be carried through from the Middlesex to the Surrey shore. The longest tunnel under water is that, two miles in length, of the water-works at Chicago, United States. This tunnel, although but 5 ft. in diameter, is carried out to where the water above it is 40 ft. deep, the tunnel itself being 30 ft. below the bed of Lake Michigan. There is also a tunnel under the Chicago river at the the same place. At home we have no less than 3 schemes for tunnelling beneath the Mersey, at Liverpool, and 3 for tunnelling beneath the Severn below Gloucester, and in both instances one of the 3 schemes

will in all probability be yet carried out. Provided only the bed of the channel or river beneath which the tunnel is to be made is nearly or quite impervious, under-water tunnelling is no more difficult than underground tunnelling. And there may be shafts, even, to under-water tunnels, just as the Chicago lake tunnel has its shaft through which the water supply is taken, but which was employed, during construction, for the ordinary purpose of giving a second working face and for discharging the excavated materials—this shaft being 2 miles from shore. This tunnel was carried through a continuous bed of tenacious clay, as impervious to water as marble itself. But in the proposed Channel tunnel, to be made at a depth of about 500 ft. beneath the surface of the sea, it is needless to remark that a single fissure in the chalk, however narrow, would be rapidly widened by the tremendous abrasion of water under the great pressure of 200 lbs. per sq. in.; so rapidly that probably no efforts to clear the workings could be expected to succeed. A fault of great vertical magnitude is well-known to divide the chalk beneath London, although neither the precise line of this fault, to within a few yards, nor the width, if any, to which the chalk bed is separated at the point, is known. Whatever may be inferred from the geological analogies of the chalk on the English and French coasts, it cannot for a moment be positively asserted that a fault beneath the middle of the Channel does not exist, nor, it is as well to add, can it be asserted, on the contrary, that a fault does exist. The question can only be settled by a trial heading or driftway; and, whatever the real danger, there are plenty of navvies and miners who, knowing no fear, are ready and willing to face it, when the eminent engineer, whose name is connected with the proposed undertaking, finds himself in a position to give the word. Let 2 headings, each 11 miles long, once be carried out to meet each other beneath mid-channel, and the success of the tunnel, so far as its completion is concerned, is assured. It would be a matter of long and tedious boring and blasting, and one in which uncertain millions would certainly be swallowed up, but it would all come right at last, supposing, of course, that by previous experiments upon that thirsty material, chalk, no excessive infiltration of water under a maximum pressure of 200 lbs. per sq. in. was found to take place, and there would be 24 acres of roof of each heading of 9 ft. in width, the ceiling, if it may be so termed, of each heading of 9 ft. width amounting to rather more than an acre per mile.

There are two distinct schemes for a tunnel beneath the bed of the Channel, but the same general certainties and uncertainties apply to both. It is only from geological inferences that either can claim superiority over the other. It would require space far beyond the limits of the present paper to deal even with the geological aspect of the question alone. It is but right, however, to remark that geological evidence, as far as it goes—for the materials at command are scanty—points strongly to the probability of the complete continuity and homogeneity of the chalk which forms the upper beds of the broad and shallow submarine valley separating our island from the Continent.

Bridging, steam-ferrying, and tunnelling fall within the ordinary range of engineering. But no engineer has yet attempted to lay down a railway upon the bottom of the sea itself—a railway, the passengers of which, like the Israelites of old, should go over, or, rather, under, dry-shod, not only with a dense wall of water on either side, but with 30 fathoms or so over their heads. It is not the purpose, here, to enter at length upon the relative advantages and disadvantages of subaqueous ways—a term employed merely to distinguish railways on the Channel bed from those in tunnels beneath it—as compared with railways deep down in the chalk. As, however, the remainder of the present paper will be chiefly devoted to the examination of the mode of constructing subaqueous ways, it will be but fair to enumerate the objections which may be urged against them. They are these:

Beyond some amount of uncertainty necessarily attaching to the laying of such ways, they might, possibly be injured by the dragging anchors of vessels, or broken in two by the sinking wreck of an iron steamer dropping upon them. They might, possibly, suffer at the shore ends, where they rose to within the action of the waves in heavy storms. They could always be destroyed wantonly, and with little fear of detection, by sinking a charge

of gunpowder upon them, at any portion of their length, and then firing the charge, at a safe distance, by electric wires. It might be urged, too, that a large tube, especially where it rose like a huge groyne, in-shore, might cause injurious disturbances in the Channel bed, thus affecting navigation. In any case, the tube could be started and carried forward from but one end only, as it would be out of the question to attempt to bring together, water-tight, the two closed ends, or for that matter the open ends, of two tubes in mid-channel.

These appear to be the principal, if not all, of the possible objections which could be urged against subaqueous ways. The weight of these objections depends probably more upon the individual opinions of those who advance or refute them than upon any evidence capable of demonstration. As for the dragging of anchors, the various proposals (and there are several) for tubes on the bed of the Channel provide for routes well off the Varne and Colbert banks, and, it need hardly be said, miles to the westward of the Goodwins; routes upon which vessels would seldom have occasion to anchor at all, even in the worst storms. Were an anchor dragged, however, with a force of even 150 tons —the highest chain cable test of Lloyd's proving house—this could not make any definite impression upon a continuous tube weighing 8 tons or more per foot of its length, for to move at all at least a quarter of a mile of tube weighing 10,000 tons would have to be dragged upon the Channel bottom. As for breaking the tube, say $4\frac{1}{2}$ in. thick of cast-iron with a lining of one foot of brick work, the chances would appear extremely improbable. But a greater security will appear when it is considered that a cast-iron tube, say 14 ft. in diameter, and having no outer flanges, presents no point upon which an anchor could bite. The chances of an iron vessel foundering exactly across the line of the tube are, to say the least, by no means numerous. In shore, that is to say in shoal water, the tube would require to be protected by strong parallel breakwaters, as much to prevent vessels grounding across it as to prevent the action of the waves upon it. The risk of possible destruction by malice—the crushing in of the crown of the tube by the explosion of gunpowder upon it in 10, 20, or 30 fathoms of water—is a risk of which each one must form his own estimate. This mode of destruction, the consequences of which would be irreparable for all time, could most certainly be resorted to by hostile or merely malicious feeling, with almost no chance at all of detection, whereas neither a bridge nor a tunnel deep down in the chalk could be destroyed without some difficulty, and the certainty of the timely discovery of the attempt.

The various proposals for laying subaqueous ways upon the bed of the Channel are as distinct from the ordinary range of bridge and tunnel engineering as the making and laying of submarine cables are distinct from the construction of land telegraph lines. Of what is technically distinguished as mechanical engineering, very little is now required for the construction of an iron bridge, or a tunnel in earth or rock; but the construction and laying of a subaqueous way would be, to a large extent, the work of the mechanical engineer. Such a work, upon any plan, would be one attended with many contingencies, and so far as mere ingenuity is concerned (not that the necessity for greater ingenuity is in itself an objection) the subaqueous way would incontestably require far more originality of design, for its making and laying, than any other mode whatever of crossing the Channel. But as engineers always rise to the occasion, it may be assumed that a plan, physically possible in the abstract, would never fall through from the want of that elaboration and improvement which are summed up in the mind of the engineer in the single word "detail."

Perhaps the first quasi practicable plan proposed for crossing the English Channel by means of a subaqueous way was that contained in an anonymous pamphlet printed in Dublin in 1858. The author proposed to construct a 15 ft. tube from Dover to Calais, extending it, foot by foot, along the bed of the Channel, from the English to the French coast. Starting from the English coast, within a structure named a "head" or a "bell," this head fitting water-tight, around the exterior of the tube to be extended, he proposed to put together each successive length of the tube within the head, and to push the latter forward as fast as the work proceeded, the head meanwhile

lying on the bed of the Channel. The calculations of resistance, and of the quantities to be employed in the tube itself, were carefully worked out, and so far as the author has tested them, these calculations were correct upon the *data* assumed. This mode of construction insures the advantage, if it be an advantage, that each portion, whether of 10 ft. or even a mile, of the length of the tube, once laid, is not again disturbed at any subsequent stage of the work. But the designer appears to have foreseen an element of possible weakness when he asserted that even were the tube rolled over in the Channel no harm could result to the passengers, and no interruption to the train service. Inasmuch as the atmospheric system was relied upon for propulsion, and the passenger compartments were to be shot through circular tubes, it might not perhaps make any difference to the passengers whether their carriages bottomed upon one part of the tube or another; but it would be interesting to know what would become of the shore ends, and for that matter, the passengers themselves within the tube, if a few miles of the latter were really to turn over in mid-channel.

The anonymous idea of 1858 has been lately worked out in much greater detail by an eminent English engineer, whose labors have been assisted by an Austrian member of the same profession. Their plan, which has now been for some weeks before the public, provides for a cast-iron tube of 13 ft. internal diameter and 4 in. thickness, to be carried out in 10 ft. lengths, each length being formed of six segments. The work of putting together the successive lengths of the tube is to be performed on the bottom of the Channel, within a cast-iron "bell," as it is termed, this "bell," or shield, being 80 ft. long, 18 ft. in diameter, and 8 ins. thick. The tube is to be packed, water-tight, within this bell, and the bell itself is to be forced forward, 10 ft. at a time, after that length of tube has been added to the portion already laid. For forcing forward the bell 4 hydraulic presses, each of a maximum force of 1,000 tons, are to be employed. The details of the scheme are most ingenious; at the same time perhaps not too much so, for many a mechanical project has been ruined by too much ingenuity. It is evident that from the very confined space, but a dozen men or so at most could be effectively employed at a time within the end of the tube, in putting the segments together, although a much larger number, were they required merely to work the hydraulic machinery, could find room in the forward portion of the "bell," and it is evident that the rate of progress of the tube would be measured by the rate of working of the dozen or so of men employed in putting the segments together, the segments being brought, when the tube was nearly completed, from a distance of say 20 miles through the tube itself. The segments and bolts once made ready on shore, the whole labor of putting the tube together, the whole task of maintaining its intended course, and the whole of the responsible duty of inspection as the work goes on, would be performed under water, in an artificial light, and with artificial ventilation, and where, upon the occurrence of any accident, causing the sudden inroad of water, all within the tube must hopelessly perish. Should the tube crack and fill with water during the process of laying, it is also hopelessly lost, since no moorings are or can be attached to it during the process of laying or afterwards. That the tube might crack, at some point, while the shield was being advanced under a force, according to the depth and the nature of the bottom, of from 1,000 to 4,000 tons, would be nothing very improbable. And what might be the chances of leakage, with nearly 65,000 joints made in the dark, or, rather, in a very feeble light, and under water, must be left to the imagination, the joints themselves being upwards of 200 miles in aggregate length, and, taking them as 8 ins. wide each, presenting a total surface, for the two parts brought together, at each joint of about 34 acres. There is, probably, nothing physically impossible in the scheme, although it would be one attended with many improbabilities of success. Nor could this plan of construction be adapted to the irregularities of the Channel bottom, upon which the gradient would occasionally require to change from level to 1 in 100, making a difference of 1½ in. between the joints on the upper and lower sides of the tube, thus necessitating special castings, or involving the risk of leaking. The particular tube now under consideration would have a multitude

of external flanges, and it is not improbable that it might suffer from dragging anchors. These flanges and ribs are not essential, however, to the general plan.

While it is fairly open to doubt whether any of us will ever live to see a practical railway tube laid across the Channel—open to doubt, too, whether such a tube is even required at all—there is still a sort of bewitching interest in speculating upon the mere possibility of such a thing ; and it is thus that this meeting may be supposed to have resolved itself into a committee of inquiry upon this very point. Can the tube be made at all? Can it be made before those now unmarried shall have lived to see their grandchildren? If it can be done, and done off hand, so much the better, always provided that the tube is what is wanted. Here, as with Mr. Midshipman Easy, there is no help for it but to "argue the point." Assuming, then, for the sake of argument, that the particular tube now under consideration can be made, and safely laid, can it be done, as its proposers estimate, within a period of three years and a half, or only within from six to ten times that space? The tube is to be made of something like half a million tons of cast-iron, and to believe that it can be made at the rate of 100 ft. forward a day, as estimated, is to believe that nearly 500 tons of castings, all ready, or, rather, *supposed* to be ready, to go exactly together, each casting weighing about 8 tons, can be loaded on horse trucks, or hand trucks, and carried through the tube itself for an average distance of ten miles, unloaded, placed in position, the thousand or more connecting bolts, for which the holes have been previously drilled, secure in their places, the joints made good with lead, and a great deal of other work carried on, all within a confined space, within which, partly from the machinery to be employed, hardly more than a dozen men, if as many, will have room to work at all. The British Association was lately occupied with a most able and most interesting description of this plan, and the Society of Arts may therefore be inclined to examine this, the very important point, which, at the recent meeting of the Association at Exeter, appears to have escaped all examination whatever. The "point" might be "argued" still further, but let argument be dropped now for individual consideration of the subject.

Another plan of making and laying the tube has been proposed—a plan based, like the others, upon a general estimation of what is possible and probable. It is to construct the tube, in long lengths, within a dry dock in shore, and to float out these lengths, successively joined together, until the opposite coast is reached. The tube would be floated—not, certainly, upon the surface, but by means of buoys, just clear of the bottom, the tube being again grounded as soon as it had been advanced a length.

Few propositions, perhaps, connected with engineering, upon which the writer has ever reflected, have, at the first view, presented more apparent impracticabilities than this one. But the more he has examined it, the more have the means by which these difficulties may be overcome, disclosed themselves. It was enough to know, from the first, that the plan was not in contravention of any law of nature, and therefore was not impossible. Like each of the other plans already noticed, its execution would necessarily be in the face of tremendous difficulties—difficulties which, perhaps, not one of the various projectors of channel tubes have fully estimated, and which, it is beyond doubt, they have not, because they cannot have, fully provided for. But the whole progress of engineering has shown that what were once seeming impossibilities have long since become useful and familiar facts. The difficulties supposed to be once overcome, it is plain that a plan whereby, say a thousand feet or more of the tube could be put together in a single day, in the open air, as many men being employed upon it at once as could find room to work with advantage upon that length, would have a manifest superiority over any other in which each length of a few feet, say ten, must be wholly completed before another length could be begun, and especially in which the whole work of making up the tube is to be carried on within the tube itself, the parts being brought to the front in trucks drawn by horses to a distance successively increasing to twenty miles.

In no way could the segments of a tube be so rapidly got into place and secured together as in a dry dock, the semi-circular bottom of which, of cast-iron, would conform exactly to the tube itself. The seg-

ments would be lowered into place, those for the lower half of the tube centring themselves, while those for the upper half would be temporarily supported upon centres so made as to be readily taken down when the key segment was got in and secured. The seaward end of the tube, of great strength, would, of course, be closed, and it would be provided with suitable fittings for attaching the powerful hauling-out tackle, to be used when the successive lengths were floated. The dock gates would close around the tube so as to form a water-tight joint. The tube would be of such dimensions and thickness that, previous to putting in the brick lining, its own weight would be, as nearly as possible, exactly the same as that of the sea water displaced, so that of itself it would, so to speak, neither sink nor swim. Approximately, a 14 ft. tube would displace about 4½ tons of water for each foot of its length, and it would of itself weigh about 4¼ tons for each foot of its length when its thickness, allowing for all flanges and bolts, was 5 in., or say 4½ in. between flanges, and this would be the proper thickness for strength, irrespective of any consideration of displacement. The weight of the tube would require to be very accurately adjusted, since a difference of thickness of 1 in. would cause a difference of weight of 900 tons in a 1,000 feet length, hence a difference of but $\frac{1}{1000}$ of an inch would represent very nearly a ton in weight. Each length would require to be brought to the exact limit of flotation by means of adjustable weights. As the tube would require to be adapted to the irregularities of the bed of the channel, each length of a thousand or more feet, would have a ball and socket joint, and it would be here, and here only, that the sinking weight would be applied, and the holdfasts for the lifting and sinking tackle attached. Probably 100 tons might be necessary to prevent any movement of the tube, especially in-shore, from the force of the sea, for at a depth of a few fathoms the force of storms would not be felt at all. The tube being made in segments, the construction of ball and socket joints would be attended with no difficulty. They would require to be made of great strength, not merely to provide sinking weight, for they would receive the whole strain of the hauling-out tackle when the tube was advanced seaward. A thickness, for the ball and socket, of 8 in., this thickness being continued a ltttle more than 10 ft. each way, would give 100 tons of sinking weight. The motion at these joints would be but slight; yet this slight amount of motion is none the less necessary to enable the tube to adapt itself to varying gradients. It is at least remarkable that any strictly rigid tube should ever have been proposed, as more than one has been, for a line having gradients varying from nearly level to 1 in 100.

When a length of tube had been completed and was ready for launching, its in-shore end would be closed water-tight, the buoys made fast in place, the dock gates opened, and the sea admitted, upon which the tube would be drawn up well clear of the bottom by means of the adjustable tackle connected with the buoys, and the whole of the tube, of whatever number of connected lengths of 1,000 ft., would be drawn out to sea for a distance corresponding to the length last added. It would then be lowered again upon the bottom, the in-shore end of the tube being left well within the dock gates, which would then be closed, and the water in the dock pumped out.

In buoying and advancing the tube, especially when extended nearly 20 miles, it contained nearly half a million tons of cast-iron, the chief resistance, in starting, would be, occasioned by, not its weight—for except at the ball joints it would have no preponderating weight in the water—nor by its skin friction, for this at a rate of motion of 1000 ft. only in an hour would be comparatively trifling; but the real resistance would be from inertia. It might be supposed that as much effect would be produced by the hauliing-out-tackle if made fast to the Rock of Gibraltar as if to a great iron sea-serpent, 20 miles long, and weighing half a million tons. But let us see what this enormous resistance would be. Let the rate of onward motion of the tube be 3 ins. per second, a rate at which 100 ft. would be gained in 400 seconds, or 1 hr. 6 mins. and 40 secs.; not so very long a time after all. To give this rate of motion would require the same force as would be necessary to lift the whole weight to a height of the $\frac{1}{85}$th part of an inch, a distance almost too insignificant to deserve consideration until it is understood that 500,000 tons are to be lifted to that height. It is then that

the $\frac{1}{32}$th part of an inch begins to look respectable, the work done being equal to that in lifting 1 ton to a height of nearly 500 ft., or, in other words, 500 foot-tons, which is about the energy contained in a 32 lb. cannon ball when it leaves the gun fired with a full service charge. But these 500 foot-tons do not need to be exerted within 1, 2, or 3 mins., and if a quarter of an hour be taken to get the sea-serpent under weigh, the mean rate of progress during that time being 1½ in. only per second, the tube will have progressed 112½ ft. before it is in full swing, and thus the pull will average less than 4 tons during that time, after which all further resistance from inertia ceases. Now 4 tons is a little more than the breaking strength of the little Atlantic cable of 1858, and is well within the working strength of the steel wire ropes employed to haul Fowler's steam ploughs. Next comes the resistance of skin friction. The surface of the tube, supposing it to be 14 ft. in diameter and 20 miles long, and having no outer flanges, would be nearly 107 acres, whereas a ship like the Hercules has but little more than three-quarters of an acre of immersed surface when ready for sea. But the Hercules has run nearly 15 knots an hour with a net thrust upon her screw shaft of about 50 tons, the resistance being nearly all skin friction only. Skin friction is believed to increase as the square of the velocity, so that the 1,000 ft. an hour of the sea-serpent are to be compared to the 90,000 ft. an hour of the Hercules, not in the proportion of 1 to 90, but in that of the square of 1 to the square of 90, or as 1 to 8,100. Thus the Hercules, weighing 8,600 tons, requires 50 tons pressure at the stern to drive her at her full pace, while the serpent, with a skin nearly 150 times more expansive, and a weight nearly 60 times greater, would nevertheless, upon the law of the square, require a pull of less than 1 ton to tow it by the nose, if serpents have noses, all the way across the Channel, its inertia having been already overcome. And yet this mass of iron, if thrown into the form of a cube, would measure about 136 ft. on a side.

That the tube would follow its nose, in a straight line, and not in the zig-zag outline of a Vandyke border, known in America as the Virginia fence pattern, may be safely concluded, not only from a consideration of the reasons which would compel it of necessity to follow a straight course, but from an analogy afforded by Mr. Macsweeny's jointed steamboat, the Connector, which plied a few years ago between Newcastle and London, and by Mr. John Bourne's trains of connected boats on the Indus. Although neither of these systems proved commercially successful, both demonstrated that a long train of boats connected together will follow as true a course upon water as will a long train of wagons on a railway.

The tube would be hauled forward as each fresh length was added, by tackle worked from a vessel steered well ahead, on the true course, and there moored fore and aft, to prevent swinging out of her position, although the whole work of advancing the tube would or should be performed at slack high water. In such a great work, so important to the commercial interests of the whole world, it is not unreasonable to suppose that a convention would be entered into by all, or nearly all, commercial nations sanctioning the authority of a marine police to guard the hauling chain from dragging anchors.

But now come, perhaps, the principal questions of all. The maximum tidal current, at spring tides, in that part of the Channel where the various proposed tubes are intended to be laid, is, by Burwood's Tables, 3.3 knots an hour, or 5.57 ft. per second. This is, however, the surface velocity in mid-channel. The velocity at the bottom, in the deeper portions, is probably *nil*. In a communication recently made public by Mr. Cromwell Varley, the eminent telegraph engineer and electrician, occurs the following interesting and even amusing passage :

"It is well known to all nautical men, that the action of the waves decreases very rapidly in descending. I believe I am correct in stating, in proof of this, that a diver, engaged upon the wreck of the Royal George, accidentally left his spectacles on the wreck off Spithead. The depth of water was about 16 fathoms. A violent storm prevented him from resuming operations for about 9 days, and, on again descending, he found his spectacles in the place were he left them.

"It is also well known to all nautical men, that currents extend, as a rule, to only a small depth ; and it is a common practice to moor a boat in deep water, by tying a kettle or some heavy object to

a line, and dropping it overboard into the comparatively still water. This mode of anchoring has been frequently used by the surveyors in the Atlantic.

"As a further proof of the complete stillness at the bottom, I may mention the cable that was laid from Varna to Balaclava. This plain gutta-percha covered wire was wholly uninjured by those terrific storms which destroyed so many English vessels."

With 100 tons of anchoring weight at the shore end, and with the same weight at distances of every 1,000 ft., and with the immense inertia of a tube weighing 4,500 tons between each pair of sinking weights, there would appear to be but little danger from the action of storms—a conclusion borne out by the fact that iron sewer pipes are often extended well out to sea, as at Brighton, and remain there without disturbance. The waves come end-on with the tube, and are harmlessly divided, whereas, did they strike it athwart, they would lift it upon the beach. Experiment, during a single winter, would determine whether even so much as 100 tons sinking weight would be required at each 1,000 ft. It might turn out that 50 or even 25 tons would suffice, in which case the work of lifting and grounding the tube, as about to be described, would be very greatly lessened. The most critical point in the whole scheme is probably that of lifting and lowering the tube at each advance. Before going into this, it will be as well to see what is to be done at each sinking weight or ball joint in deep water, say 33 fathoms at high tide. There are 100 tons of dead weight to be lifted, besides the inertia of 1,000 ft. of tube to be overcome, and there is also the weight of the lifting chain itself, and its supporting buoy. Taking the weight and inertia to be overcome as 150 tons, and supposing the lifting chain never to be strained beyond 3 tons per sq. in., the sectional area of the chain would be 50 sq. in., so that each 15 ft. of its length would weigh a ton. As the chain would commence two fathoms and a half from the bottom, we will allow that for slack, and its own weight would thus be between 13 and 14 tons. This it would be necessary to buoy with the utmost care, for, once lost, the chain could never be recovered in water of greater depth at most than 15 fathoms. The buoy, weighing probably 5 tons of itself, should have at least 20 tons of additional supporting power, and would thus require to be of a capacity of 875 cubic ft., corresponding to a cylinder 8 ft. in diameter and 18 ft. long. Were it not that the buoys must be kept out of the way when the lifting tackle is attached, they would be best secured by passing the chain through them in the central pipe with secure stoppers, top and bottom. As they would, in any case, continue to float, this might, after all, be the best way of attaching them, when the stoppers were taken off at each lifting and lowering.

In getting into deeper water the chains would require to be lengthened, in 10 ft. lengths, at every few advances, and in shoaling they would also have to be shortened in proportion. The lifting and lowering would be performed from a vessel alongside, and the lifting itself be effected by steam, acting directly upon the lifting chain; that is to say, a strong steam cylinder 5 ft. in diameter, and permitting of a stroke of piston of 20 ft., would be supplied with steam from a small boiler worked at from 125 lbs. to 150 lbs. per sq. in., giving a lifting force of from 150 to nearly 200 tons. It is only by a direct steam lift that the effects of pitching and descending in the lifting vessel, and the varying level of the sea as the tide ebbs or flows, can be provided against, and that the elasticity of strain, necessary for the preservation of the chain, and thus of the tube itself, could be secured. There are many details which would require to be carefully worked out before such an undertaking could be safely begun, but, without entering at greater length upon them here, it may be said that the principles upon which safety at each step would be reasonably assured have been considered with some care, and that there are no difficulties in the way which appear really insurmountable. It is not to be forgotten that a lifting vessel would be required at each 1,000 ft. length, making no less than 110 in a length of 21 miles. There would be no difficulty in chartering the number, and the cost of the requisite fitting would not, in comparison with the whole cost of the work, be excessive.

The practicability of this making and laying a tube could be approximately ascertained by making two 500 ft. lengths of tube half size, or 7 ft. diameter and 2¼ in. thick, closing their ends, and sinking

and lifting them by means of 3 tug boats in different parts of the Channel. These lengths would weigh, including sinking weights, about 925 tons. If the experiment succeeded perfectly, as it should, in calm weather and at slack high water, it might be continued in rough weather and under the influence of the tidal current. The exposure of one or both these lengths, for a single winter, lying end-on to the shore, would afford very valuable experience. It is always to be borne in mind that after the tube is once laid, the brick-work lining and permanent way which will then be added will more than double its weight.

The tube, when laid for its whole length, would be bolted together at the ball joints by means of inner flanges, the whole then lined with brick-work and an inner iron casing, a permanent way laid, and would then be worked upon the atmospheric system.

The cost of the whole may be roughly estimated as follows:

500,000 tons of castings fitted ready for placing at £6	£3,000,000
Brick-work lining	250,000
Dry dock, fixed plant, etc.	500,000
Floating establishment	1,000,000
2,500 workmen for two years at £100 per annum	500,000
Interest, during construction	500,000
Engineering and contingencies	250,000
Total, exclusive of approaches	£6,000,000

The plan suggested can claim no other advantages than these, viz.: its practicability being assumed, it could be carried out in two or three years, including all the time expended in preparatory works. Almost any number of workmen might be effectively employed at the same time, and that in the open air, in full daylight, and out of the way of danger in case of accident. The tube would furthermore possess a flexibility which would insure its following the irregularities, both vertical and lateral, which, with a careful survey in advance of the work, would naturally be found even on the comparatively smooth bed of the Channel.

It forms no part of the objects of the present paper, however, to put forward claims in favor of submerged railways. It is admitted, on all sides, that they cannot be made at a less cost than from £300,000 to £500,000 per mile. It is by no means certain that, even for the saving of half an hour and an immunity from sea-sickness, the majority of passengers would prefer a submarine journey of three-quarters of an hour, with the knowledge that but a few inches of iron were interposed between them and a second deluge. The fact that almost countless fleets of shipping were crossing 50 or 60 yards overhead; that a single ship, foundering then and there, and making its fatal plunge upon the tube, might work even greater destruction than its own; the reflection that scoundrels in the pursuit of mischief, or villains in the service of the devil, could at any time, and with almost perfect impunity, dispose of the tube for ever—all this would be anything but reassuring to the timid, and it would have its due weight with the strong.

In respect of economy merely, the interest upon a cost of £6,000,000, supposing the work to be carried out for that sum, and the money raised upon the guarantee of the English and French Governments at 4 per cent., would be £665 per day, or £231 per mile per week. It is not, perhaps, necessary, however, to assume that the work is to be undertaken as an immediately paying speculation, since other considerations of importance are involved in the question.

It is not to be lost sight of, however remote the bearing of the question upon the present subject may appear to be, that a sudden demand, within a couple of years, for half a million tons of cast-iron, not for export, and not for immediately productive employment at home, would most certainly inflate the iron trade, and, indirectly, affect nearly every branch of our industry. If the price of pig-iron advanced, as it not unlikely might, to the extent of 20s. a ton, this means 25s. or 28s. on rails, 30s. to 35s. on bars, and from £2 to £3, or even £4, on the higher qualities and lighter sections of iron. The very home demand, whereby we would be literally throwing our iron, and with it our money, into the sea, to no immediate profit, would give to other nations an advantage of which they would not be slow to avail themselves. Half a million tons of pig iron, when converted into rails, bars, or plates, and allowing for loss in conversion, would suffice for 2,000 miles of double line railway, or it would construct 75 miles of heavy iron bridges, weighing a ton per foot, or it would serve the shipbuilder for 250 hulls, such

as, when fitted, would register their 3,000 tons each. The sudden abstraction of such a quantity for a single work, having no immediate prospect of success, might be attended with consequences which the whole country would long have occasion to deplore.

It has been mainly the object of the present paper, however, to examine into the engineering merits of the various schemes proposed for crossing the Channel, and the writer cannot close without expressing the belief that the balance of certainty, economy, and, all things considered, the safety and even the comfort of the travelling public remains with a large and suitably organized Channel ferry service.

HYDRAULIC MACHINERY FOR WAREHOUSING GRAIN.

By Mr. PERCY G. B. WESTMACOTT.

From "The Mechanics' Magazine."

The subject of the paper of which the following is an abstract was a description of the hydraulic machinery for warehousing grain at the Liverpool Docks. Blocks of warehouses have been erected by the Mersey Dock and Harbor Board, ably designed and executed under the supervision of Mr. Lyster, the dock engineer, for the stowing and conditioning of grain and bread stuffs. The dock upon which they are situated is 570 ft. wide by 230 ft. broad at one end and 180 ft. at the other, with a depth at high water spring tides of 34 ft. over the sill of the gate. The blocks on the east and west sides of the dock are 650 ft. long, and that on the north end 185 ft., the whole range being 70 ft. wide. The buildings contain five stories. Above the fifth or upper storage floor, and partly in the roof, is placed the machinery floor, and below the quay level are wells and arched subways for the reception of the underground machinery. The total storage capacity of the floors, exclusive of the quay floor (at 4 qrs. to the square yard) amounts to 196,000 qrs. of grain. The ends of the east and west blocks are constructed to receive iron chambers for conditioning grain on the Deveraux system, in order to prepare it for the market by drying. The steam-engine, the prime mover of the whole plant of machinery, was of 370-horse power, and that, in addition to driving the machinery in the warehouse, supplied power for working the lock machinery and the bridge over the entrance, consisting of two 60 ft. and one 50 ft. bridges, twelve sluices, ten powerful ship capstans, and twenty-four machines for opening and closing the lock gates. From returns taken of the importation into Liverpool of the different descriptions of breadstuffs for the years 1858–63, it was estimated that the warehouses should be constructed capable of working 250,000 tons per annum, irrespective of other ordinary merchandise.

Having described the principal processes required to be performed by the machinery, and the best means likely to secure the requisite power, and especially the kind of power, and the most convenient, practical, and least costly method of applying and distributing that power, the writer stated that it was found after experiment that no system of motive power, or combination of systems, could be found to meet those requirements in the aggregate with so much effect, convenience, and economy as the hydraulic system. Having noticed the facility with which this power had been conveyed for long distances at the Birkenhead docks, and also the advantages, or otherwise, of propelling grain horizontally by means of screws, the author stated the results of the latter system. At sixty revolutions per minute (the maximum effective speed) grain could be discharged by a screw in use at a certain brewery at the rate of $6\frac{3}{4}$ tons per hour, being at the rate of $\frac{1}{15}$th-horse power for every foot run. With a screw subsequently put into operation of 12 in. diameter, and driven at the rate of seventy revolutions per minute (the most effective speed), thirty-four tons of grain per hour were discharged. The effect upon the grain in the latter case was marked, it being rubbed and polished, and thereby improved in marketable condition. But the long distance through which the grain had to be conveyed horizontally, amount-

ing collectively to 7,000 ft., and the power required to perform the operation, even with the best form of screw, rendered it expedient to seek some other method less absorbent of power, and recourse was had to endless travelling bands.

Experiments were made with a 12 in. band, constructed of canvas and india-rubber. It was found that a speed of 9 ft. per second could be attained with heavy grain, and still more with peas. The amount of grain discharged by the 12 in. band at the speed of 8 ft. per second, was at the rate of about 35 tons per hour. Further trials were carried on with an 18 in. band, made of 2 plies of stout canvas, covered with vulcanized india-rubber. To meet the requirements of passing grain from off the straight bands to either side at certain points along the travel, several contrivances with air blast, and brushes driven from the band itself, were tried, but with indifferent success. Both methods were objectionable on account of raising dust, and the friction of the brush proved in time injurious to the band. The idea then occurred of diverting the line of the current of grain by means of an upward deflection of the band, thus casting the grain clear from the band into the air for a short distance; it could then be received upon a band travelling in any other direction, and, if necessary, could be passed round the warehouse from one side to the other, or even make a circuit of three sides of the block, according to the method in which it was intended to dispose of it, or the place in which it was to be deposited. There were 56 spouts, 8¼ in. square, from the upper to the various other floors. No difficulty was experienced in keeping the grain on the band, but it was found necessary to glide the grain on to it from the feeding hopper through a spout rather less than half the breadth of the band, at an inclination of 42½ deg., which would impart a velocity to it of falling approximating to that of the band. The maximum amount of heavy grain conveyed by the 18 in. band was at the rate of 70 tons per hour; the power required for driving the band when fully loaded was ascertained to be equal to about $\frac{1}{70}$th-horse power effective per foot run.

The paper then described the boiler and engine, etc., and also other apparatus with which the warehouses are furnished, including the cranes and the two accumulators, each of which latter is weighted with a load of 70 tons, acting on a ram 17 in. diameter, and the auxiliary accumulator with a load of 100 tons, acting on a 20 in. ram. The form of tub in which grain is lifted from the hold of ships, and the hoppers through which it is passed for various purposes, having been minutely described, the author detailed the construction and capacity of the elevator, which consists of a wrought-iron bucket, capable of containing about 21 cwt. of grain. It was slung in an arrangement of bars and levers, provided with guiding rollers, which enabled the bucket to run in special grooves to the top, for the discharge of the grain into the upper hopper, which communicates with the same cross bands that convey the grain from the hopper under the crane. Casks, bags, and other merchandise might be raised or lowered by two classes of machine—one by means of the hydraulic cradle hoists, of which there were 12; the other by means of 20 jiggers. Twelve double-acting 10 cwt. jiggers had also been added to the plant in the central block, to lift and lower goods to and from railway wagons. The paper lastly directed attention to one of the great advantages which the hydraulic system possessed in so eminent a degree, namely, the facility afforded for the extension of power to any point where the demand for additional contrivances to save time and hand labor was felt.

According to official statistics, 158 accidents occurred on Prussian railways in 1867. The train ran off the rails 206 times, there were 68 collisions, 432 times the carriages or engine were injured, 9 persons travelling on the train were killed, and 21 in other ways, while 68 were more or less seriously injured. The causes of the accidents were as follows: 124 arose from the state of the atmosphere, snow, fog, wind, etc., 25 from accidental obstacles on the line, 4 from obstacles intentionally placed there, 11 from the carelessness of officials, 60 from the mistakes of engine drivers, and 41 from the bad state of the line. The rest were the results of faults in the locomotives, carriages, etc., or of undiscovered causes.

THE RANSOME PROCESS.

From "Engineering."

Almost every one is familiar with the ordinary process by which Mr. Frederick Ransome manufactures artificial stone, and knows how the sand, mixed with silicate of soda, is treated, then with chloride of calcium, with the result of their mutual decomposition and reformation as silicate of lime and chloride of sodium, the former living as an indestructible bond throughout the stone, the latter soluble and easily removed. The sand, after being dried, is worked up in a mill with the soluble silicate brewed from caustic soda and flints, the latter being dissolved by the former, and evaporated down to a specific gravity of 1.700. The plastic mass thus produced is obedient to the will of the moulder, and can be manipulated into any form, from a cube to elaborate screens, such as those decorating the India Office; from a grindstone to an exquisitely chiselled fountain, like that recently erected in the public gardens at Hong Kong. The mass so prepared is then saturated with chloride of calcium, applied either simply by immersion, or assisted by the action of an air pump, in either process the solution being gradually heated to a temperature of 212 deg. Fahr. Mr. Ransome has recently made some further important improvements, which promise great results.

These consist, first, in submitting the moulded mass to the indurating action of the chloride solution at a higher temperature in closed chambers connected with a steam boiler. When this has been carried on for a sufficient length of time, by opening a cock, the solution is forced by steam pressure into a separate chamber, leaving the stone to cool gradually in partial vacuo, by which all dangers of cracking is avoided—a casualty which is liable to happen when large masses are exposed to rapid extremes of temperature in the open air.

The next feature in these improvements lies in the ingenious method adopted by the inventor for extracting the soluble salts of calcium and sodium from the body of the stone, which is effected in the same closed chamber by the admission of steam (or steam and water alternately), which, as it condenses and becomes saturated with the salts referred to, is returned into the boiler, where the steam is generated, and the chloride of calcium is again made available for future operations, thus obviating the serious loss incurred by washing the stone in the way hitherto adopted.

It is gratifying to learn that the manufacture of this stone is being adopted even in most distant parts of the globe. We have already, in previous notices, informed our readers that manufactories have been established for its production in India, America, Australia, Belgium, Denmark, and Sweden. But little actual progress has, however, been made in the practical introduction of the Ransome process in the United States. It is true that the patent rights for that country were advantageously disposed of some years since, and that the proprietor in America has made capital by the sale of licenses; but ignorance or indifference, on the part of the original purchaser, prevented his licensees from developing a large and most lucrative branch of industry. This being the case, it is satisfactory to find that one of the would-be manufacturers in the United States has taken the initiative, and is endeavoring to redeem the time lost and the capital expended in useless experiments. The proprietors of the patent right for the State of California have established large works in San Francisco, under the title of the Pacific Stone Company, for the production of artificial stone, and, but for the slight drawback of being in ignorance of the practical details of the process, would probably have developed an extensive business. Being unable to obtain the necessary information from the American proprietor, and tired of working in the dark, they have at last adopted the most satisfactory and common-sense course of coming from California to Greenwich to learn the whole course of the manufacture at the fountain head. To this end the managing director, and principal shareholder in the Pacific Stone Company, Dr. W. May, has recently arrived from California, and is rapidly acquiring the mysteries of artificial stone manufacture from Mr. Frederick Ransome, by whom every facility is offered for the benefit of American licensees. We

mention this because it is a matter much to be regretted that for so long a time the vastly important Ransome process should have remained almost a dead letter in the States, so far as real utility is concerned; the American proprietor having apparently devoted his attention to making money rather than stone, from his purchased patent right. This is, of course, at an end now, and the manufacture under this patent in America will be so much greater than it is in England as the demand for the production is proportionately increased.

THE HOLSTEIN INTERMARITIME CANAL.

From "The Building News."

EARLY ATTEMPTS FOR DIRECT INTERMARITIME COMMUNICATION.

The idea of constructing ship canals across narrow strips of land, for promoting commerce, is (according to an American contemporary) not new. From a work of Antonio Galvo, entitled "Tratado dos Descubrimentos," we note the fact that the opening of a ship canal between the Atlantic and the Pacific Oceans—"the mightiest event, probably, in favor of the peaceful intercourse of nations which the physical circumstances of the globe present to the enterprise of man"—was proposed to Charles the Fifth in 1528. And, strange as it may seem, the inquiries instituted at that time, led to the recommendation of the same lines that were planned in 1825. Still older is the project of the opening of a ship canal across the Isthmus of Corinth in the Mediterranean. It engaged the attention of Periander, Demetrius, Julius Cæsar, Caligula, Herodes, and Atticus, but it was reserved for Nero to take the first active step toward the accomplishment of this end. He completed a canal half-way, as lately ascertained by the explorations of the learned Frenchman, Mons. Grimaud de Caux. This isthmus connects the peninsula of Morea with the province of Attica, in Greece. By means of a canal cutting through this narrow strip of land, the route from the Ionian Sea to the Archipelago would be considerably shortened. Such a canal would be of great importance, as enormous quantities of grain are exported from the borders of the Black Sea to the seaports of the Adriatic.

The project of uniting the Baltic with the North Sea by a navigable ship canal dates from the zenith of Lubeck's commercial prosperity, and was suggested first as early as 1390. This project occupies at the present moment the attention of the North German Parliament, and, being one that may safely be ranked among the gigantic engineering enterprises of the present age, we have endeavored to collect such accurate knowledge with regard thereto as existing sources admit.

WHY THE PROJECT WAS STARTED.

Two reasons call peremptorily for the accomplishment of a navigable route between the North Sea and the Baltic, to wit: gain in time, and safety. The distance between the English canal to the open Baltic Sea around the promontory of Skagen is about 880 miles. It would be shortened for two-fifths of its whole length if a straight route from one shore of Holstein to the other could be chosen. Steamers would thus be enabled to make the voyage from London to St. Petersburg in five days, instead of seven, while sailing vessels would gain from one week to one month, according to circumstances.

The second reason for the building of a ship canal is still more important. According to even very incomplete statistical data, the annual number of losses of vessels in that portion of the sea is greater than that of any other equally large portion of the globe. This is the more to be deplored as the route around Cape Skagen is the only one from the North Sea to the coasts of Sweden and Finland, as well to the very heart of Russia. Indeed, it has been ascertained that the yearly loss experienced on the old sea-way amounts to three million rix dollars, or about two million dollars in gold. This sum is certainly a large one, but it must be remembered that the cargoes of many vessels are exceedingly valuable. For instance, the cargoes of the American barque Joseph

Clark and the English steamer Arctic amounted to half a million dollars in gold; the former vessel was shipwrecked in 1857, and the latter in 1860. These accidents mainly occur on the western coast, especially on the sand banks of Skagen, which for this reason has been denominated "the graveyard of ships." Indeed, small and large wrecks are seen there in every condition and at every time of the year.

It may now be remarked that there are now two channels across the isthmus of Holstein; they are, however, altogether inadequate to the existing demands of navigation. The one is the so-called Strekenitz canal, begun in 1390, and completed in 1398. It is one of the oldest in Europe, and connects the river Elbe with the Trave, uniting with the former just above Lauenburg, and with the latter about Lubeck. The second artificial water communication is known under the name of Schleswich-Holstein, or Eyder Canal, and may be found on any good map.

THE PROPOSED LINE.

This has been submitted to the world in the form of an anonymously published pamphlet, entitled "The Cutting of the Isthmus of Holstein between the Baltic and the North Sea." Lubeck is proposed as the eastern terminus of this route, while it is thought that the most feasible point for the western terminus would be Gluckstadt, upon the Elbe. This line, as shown by accurate and reliable surveys, would require no locks. It is proposed to follow the river Trave from Lubeck to a point where it approaches the Hemmelsdorf Lake. This lake belongs to the most remarkable water reservoirs of the Baltic countries; originally an inlet, as most of the other lakes of the Baltic, it is now separated from the sea by a narrow strip of maratime deposits. Hills of about 100 ft. in height protect it against all winds in such a manner that Napoleon I. designated it for a winter harbor for his Baltic fleet, when, by the catastrophe of 1813, the whole project fell into oblivion. Moreover, this natural harbor is situated in the midst of one of the most populous, prosperous, and best-cultivated districts; it is surrounded by a circle of charming villages, and only awaits the completion of the projected canal to become an excellent seaport. The length of the section from this lake to Gluckstadt is 48 miles; adding thereto the distances through the lake and from Lubeck to the Baltic, we have a total length of 53 miles, or over half the length of the Suez Canal. The cost of the execution of this work, including the construction of harbors at Gluckstadt and Lubeck, has been estimated at $23,720,930 in gold.

Should a work of this kind be executed, a yearly passage of from twenty to thirty thousand vessels through the canal might safely be predicted. Such a strait would open to the ocean the immense territory of Russia; and besides this, the Prussian coast, which is over half the length of that of France, would be made directly accessible to the open sea.

Taking all in all, the cutting of the isthmus of Holstein may safely be contrasted with that of Suez. In shortening an old way of traffic, it will contribute towards transforming the slow march of civilization in the northern European countries into one worthy of this century of steam.

THE traffic returns of the London and North-Western Railway shows an increase of £3,481. In the case of the Midland the increase is £4,456. The Lancashire and Yorkshire exhibits an increase of £282. The Manchester and Sheffield return presents an increase of £382. The Caledonian return shows an increase of £344. The Great Eastern Railway exhibits a decrease of £410. The London and South-Western shows a decrease of £1,420. The Great Western returns a decrease of £590. The London, Chatham, and Dover Railway shows an increase of £455. The Metropolitan extension of the London, Chatham, and Dover, presents an increase of £324. The Great Northern Railway return shows a decrease of £733.

THE Darien Canal project is reviving. The United States steamer Nipsic, attached to the South Atlantic squadron, is under orders to proceed to the Isthmus of Darien to make surveys and explorations, with a view to determine the best location for an inter-oceanic canal. A similar survey on the Pacific shore of the Isthmus will be made at a future day.

INDIAN STATISTICS.

From "Engineering."

A report, containing a series of statistical maps of the Indian empire, compiled by Mr. F. C. Danvers, has recently been published by order of the House of Commons. The maps, eight in number, indicate the districts and divisions of British India, the native States, the distribution of languages and dialects, the cotton districts, the principal products besides cotton, the division of the salt districts, the progress of irrigation works, and the railways, telegraphs, and light-houses of India. The native languages of India are grouped into four families—the Semitic, the Dravidian, the Thihetan and Indo-Chinese, and the Indo-Germanic. The first forms but an insignificant portion to the others; the second is divided into two branches—the Dravidian, northern and southern, of which the latter is again subdivided into three heads—the first including twelve, the second eight, and the third seven dialects. The Thihetan language, spoken in Bhotan, Nepal, and part of Oudh, is divided into 23 dialects, the Indo-Chinese into 26, and the Indo-Germanic into 11. The different dialects of the latter division are spoken by about 120,000,000, and forms the principal language of India.

The maps and statistics of trade show by inspection the condition of Indian trade from 1834 to 1868. Between the first named date and 1865, the increase was almost continuous, having advanced from £14,000,000 to upwards of £123,000,000, or at the rate of about £3,500,000 a year during that period. From 1855 to 1866 the increase of trade was most strongly marked, the advance having been from £35,000,000 to £123,000,000, being an average of £8,000,000 a year. In 1866-68 a marked falling off characterized Indian business in common with almost every national trade, the total receipts having fallen as low as £96,000,000. India is now purchasing annually £20,000,000 worth of English fabrics, and exporting to the amount of £8,000,000 in general merchandise, besides about 1,500,000 bales of cotton, 8,000,000 lbs. of tea, 37,000,000 lbs. of coffee, while the value of her indigo and silk exports is £2,000,000 and £1,500,000 per annum.

Nearly £3,000,000 annually are collected from 129,000,000 of people, by means of the salt tax, and in order to assist the realization of the duty, lines have been established at which an import duty is levied on all salt crossing them. These lines, exclusive of the Indus, Mooltan, and Berar districts, have a length of 1817 miles, which are guarded by 10,832 officers and men. It is subdivided into 10 districts, and includes an area of some 502,000 sqr. miles. The amount of salt consumed by the 129,000,000 of inhabitants subjected to the tax in 1867-68 is estimated at 13,830,000 maunds, which was obtained as follows:

	Maunds.
From the Punjab Salt Mines..........	1,200,000
Crossing the Customs Lines...........	3,730,000
From the South-East Frontier.........	7,900,000
Smuggled Salt.......................	1,000,000

The average consumption per head amounted to some 3¼ lbs., and the duty from 1¼ to 3¼ rupees per maund.

The seventh and eighth maps of Mr. Danvers's report contain, in conjunction with their subject-matter, much interesting information as to the condition and progress of public works in India. The construction of roads occupied but little of the attention of the East India Company in early times. And the organization employed for the carrying out of these works, the necessity of which was freely acknowledged, proved so defective that in 1831 the Madras Presidency abandoned all attempts at maintaining such roads as were in existence, and issued instructions that the superintendents of districts should do all that lay in their power, but without any grants from Government. In 1836 the Grand Trunk Road between Calcutta and Peshawur, 1,423 miles in length, was commenced, and has been thoroughly maintained; but it was only in 1855 that the absolute necessity of constructing an efficient system of road communication was impressed seriously on the Bengal Government. In 1860-61 the formation of a system of imperial roads began in earnest, and it was intended that each district should be provided with at least one main line, passing through the principal towns or stations of the districts, and in connection with the adjacent dis-

trict's arterial way. In addition to these, the necessary branches were to be made. At this time there were in existence some 1,994 miles of main road, and 1,145 miles of branches.

In the Punjab, road construction had advanced more successfully. Immediately after its annexation an annual grant of 5 lacs of rupees was sanctioned for public works, and the greater proportion of this sum was at first devoted to the formation of a military road between Lahore and Peshawur. In 1854 there had been 3,600 miles formed, and by the end of 1856 a length of 8,749 miles had been opened.

After the Madras Presidency had partially recovered from the difficulties which had defeated their efforts to establish an efficient system of roads, new efforts were made, and between 1837 and 1843 several new lines were opened, and the old ones improved; but it was not until 1848 that the work progressed rapidly. In the ten years, 1848-58, 4,009½ miles were opened, of which 188 miles were first-class roads, and the remainder roads of the second and third class.

River navigation also occupied much of the attention of the Government, and it was probably owing to the natural facilities afforded by the network of streams, that road construction was neglected. The Ganges, in the North-west Provinces, the Brahmapootra, in Assam, the Indus, in the Punjab and Sindh, and the Madras rivers were all largely available, and afforded means of access from the seaboard to the interior. The improvement of the navigation, the dredging of the streams, and the construction of embankments, have, therefore, given much occupation; in Bengal 2,594 miles of embankment have been made, which protect the surrounding country from inundations.

The ancient native irrigation canals, of which many existed, began to be restored in 1817, and in 1822 the Doab Canal works, which have been so severely criticised of late, were commenced. The Ganges canal, the first new work of the kind attempted, was begun on the 16th April, 1842. The canal system was inaugurated in Madras five years later, and since then large sums have been annually granted, increasing with each year, until the last grant amounted to £1,779,397.

In the early history of English occupation in India little attention was paid to the construction and improvement of harbors. There are but few good harbors around the coast, although on the Madras seaboard alone, cargo is received and discharged at no less than 144 points; the improvement of the Mutlah commenced in 1855 as an auxiliary to Calcutta; in Madras large sums have also been expended in improving several ports, and in Bombay, Karwar and Kurrachee have become situations of importance. The latter works were commenced in 1860, but were stopped for some years, being recommenced in 1868, and are now in progress.

Fifty-four light-houses protect the navigation around the Indian and Burmese coasts; some of them were built as early as 1817, but for the most part they have been constructed within the past thirty years.

Such is a *résumé* of the principal facts contained in Mr. Danvers's official paper, which possesses, to recommend it, besides the length and extent of its statistical information, a graphic delineation of the most interesting topics connected with Indian trade, and improvements in the finely executed series of maps which are comprised in the report.

The Russian Government has granted a concession of 30 years to M. Titgen, Councillor of State to the King of Denmark, M. Erickson, a merchant, and M. Pallisen, consul-general for that country at St. Petersburg, for the establishment of submarine telegraphic lines between Asiatic Russia and Osaka, Yokohama, or Nangasaki, in Japan; and Shanghai, Foudjaon, and Hong-Kong, in China. The company thus formed will ask for the authorization of the Chinese and Japanese Governments, and the Russian executive will lend its good offices in the matter. The concessionaires bind themselves to attach this system of telegraphy to a station and telegraphic line of the State in Russia in Asia.

The Greenwhich Hospital Pension of £65 a year vacant by the death of Mr. T. Bullions, chief engineer, on the 8th inst., has been awarded to Mr. Thomas Brown, inspector of machinery, from that date.

THE APPLICATION OF PHOTOGRAPHY TO SURVEYING PURPOSES.

By CAPTAIN STOTHERD, R. E.

From "The Building News."

The attention of photographers has recently been much turned to the utilization of this very useful branch of art, and many excellent applications have been discovered, the practical results of which may be seen every day. There is, for example, the very beautiful process of the reduction of plans by photography from a large to any given smaller scale, by which the saving of time and labor is enormous, and the accuracy obtained far greater than that which would result from any mechanical mode of reduction. Again, there is the photo-lithographic process, and others besides, which it is unnecessary here to enumerate. Among the most recent applications of photography is the attempt to bring it to bear practically on field surveying, and by it to obtain data from which an actual survey may be plotted as from an ordinary field-book. This has been done in Austria with considerable success; and again in the Paris Exhibition of 1867, Mons. Auguste Chevallier, No. 1 Rue de Conde, Paris, exhibited a very neat and clever instrument, designed with the same object in view.

The rapidity and accuracy with which photography, as applied in this way, is capable of recording, in true relative position, the different objects composing any view falling within the focus of the lens of an instrument, render it highly probable that at no very distant day it may come into general use for military purposes, and that instruments (if not like that of Mons. Chevallier, on somewhat similar principles) may form a part of the equipment of every army which takes the field; a description of it may therefore be interesting.

It consists of a stationary horizontal plate or table, supported on a tripod-stand, over which a movable plate is arranged to revolve, with a uniform motion, by the action of clock-work. This upper movable plate is provided with a prism or mirror, by which the image of an object in front of it is projected upon the stationary horizontal plate. By means of a simple arrangement fixed at the lower part of the tube, carrying the prism, the light can be effectually excluded at any point during the period of its rotation. As the upper plate revolves, the image of each object, as it passes in front of the prism, is projected on the lower or horizontal plate in true relative position; and if a sensitized glass be introduced in connection with this stationary horizontal plate, a panoramic view of all objects presented during a single revolution of the upper one is photographed thereon, each object being in truly mathematical relative position with all others in the same panoramic view, with reference to the central point on which the instrument revolves.

This central point at which the instrument is placed corresponds exactly with a trigonometrical station at which, in the ordinary operation of surveying, a round of angles is taken by a theodolite; and the panoramic view corresponds to a round of observations, which are, however, in Mons. Chevallier's arrangement, recorded in the form of a picture, round the circumference of a circle, described with the trigonometrical station as its centre, whereas in the ordinary mode of procedure they are represented by a series of bearings with reference to a given meridian, and recorded in the form of angles therefrom.

The opening in the upper plate through which the image is projected upon the sensitized glass, is in the form of a slit, about one-third of an inch wide in the outer circumference, and gradually tapering towards the inner circle, bounding the exposed surface, its sides being in the direction of the radii drawn from the centre of revolution of the instrument. A simple arrangement covers this slit and excludes the image till the moment for exposure arrives, when it is opened by turning a mill-headed screw. The time of exposure is regulated by the rate of the clock-work, each object being presented in succession on the sensitized glass during the interval of time taken by the slit or opening to pass over the arc of the circle corresponding to it.

The image can be cut off at any point required during the revolution of the instrument by simply turning the mill-head-

ed screw already mentioned so as to cover the opening; and thus any portion of the panorama may be photographed at will, without completing the whole revolution. The mean of focusing is attached to the upright portion, and a small telescope in connection therewith gives the power of regulating it, so that a sharply defined image may be obtained. The image produced on the glass is a negative, which may itself be used in plotting the different points of the panorama on the plan, precisely in the same way that a round of angles is plotted by means of a circular protractor; when there is time, however, a print from this negative affords a more convenient medium for this purpose. In making a survey with this instrument, a base is measured, and panoramic views from its extremities, and from other points required, are taken; and the positions of the most defined objects being laid down by plotting on the plan, by means of the pictures obtained, the remaining detail is readily inserted by minor measurements, productions, and intersections. Mons. Jouart, Lieutenant of Artillery of the Imperial Guard, has published a very interesting and detailed account of this apparatus and of its use, from his own practical experience, as a surveying instrument combining, as it does, considerable accuracy with rapidity in obtaining the necessary data for plotting. The record being self-acting, no error can arise from a mistaken entry of a bearing. If a series of views were taken from prominent points, a system of triangulation might be rapidly carried over any district of country, and on this triangulation the detail could be very readily built.

It would be very desirable to test this instrument practically, in order to obtain some idea of its working powers. As regards its disadvantages, which appear to be the necessity of carrying about a dark tent and certain photographic apparatus, and the employment of trained photographers, I would observe that, as a photographic equipment will probably form an appendage of every army that takes the field in modern warfare, the first objection is scarcely worth considering, provided the instrument itself can be made in a sufficiently portable form for transport. As regards the necessity for providing skilled photographers to work it, men with comparatively little previous knowledge will answer the purpose, if first-rate hands cannot be obtained, because the pictures to be produced are not required to be kept as works of art, but are simply to be used for plotting purposes, for which such great perfection is not necessary. Mons. Jouart states that some of the negatives used by him in his surveys were taken by men who had had only three or four days' practice in photography.

In addition to the mode of working this instrument already described, it may be used without clock-work, by simply arranging it to remain stationary at certain given points round the circumference of the circle of the panoramic view to be taken, the distance between the stationary points at which the apparatus is fixed for each view being regulated by the space on the sensitized glass on which the image of the view to be taken will be cast in proper focus. The effect of this process is to produce a series of views forming a panorama, and, in point of fact, giving a very similar result for working purposes to that obtained with the clock-work, the only difference being that in the one case a series of views is produced, whereas in the other the result is one continuous picture, extending without a break completely round the circle.

When no clock-work is used, the arrangements for exposing the sensitized glass are somewhat different from those required with the continuous action as already described, a broader space being exposed for a certain definite interval of time, and then the apparatus passed on to the next space, which is in its turn exposed, and so on till a complete circle, or portion of a circle, has been photographed. The instrument exhibited in Paris at the International Exhibition excited a great deal of interest; it is a comparatively new idea, and it is to be hoped that it will prove as useful as its inventor anticipates.

CHICAGO is going into the iron manufacture on a large scale, and with Lake Superior ores. A number of capitalists there have formed a company, and contemplate the erection of a large mill at Joliet. Wrought-iron gas and water pipes will form one feature in the production of the establishment.

IMPROVED PISTON FOR STEAM AND OTHER ENGINES.

By MR. T. H. MARTIN.

From "The Mechanic's Magazine."

At the annual meeting of the Miners' Association of Cornwall and Devon, recently held at the Polytechnic Hall, Falmouth, Pendarvis Vivian, Esq., M. P., in the chair, the following important and interesting paper, by Mr. T. H. Martin, of the Morfa Copper Mills, Swansea, was read, it being selected from amongst several other papers which had been sent in for discussion:—

The piston being the medium by which the power of the steam is exerted and transmitted through the rod to the work to be performed, it naturally forms one of the most important parts of the steam engine; consequently the duty of the engine, in a great measure, depends on the efficiency of its work. Pistons are of various constructions, but all may be classified under two heads, viz., those for single-acting and double-acting engines. In single-acting the steam is admitted on one side of the piston only, the reverse side being generally hollowed out; whilst in double-acting engines the steam is admitted on both sides alternately. It is not material in the construction of a piston whether the engine is condensing or non-condensing.

I propose to refer to each class of piston in the following order:—First, to those for single-acting pumping engines; second, to those for double-acting engines. I purpose briefly describing the form, and to point out the disadvantages attached to pistons that are generally applied to single-acting engines. They are variously constructed, as before remarked, particularly those parts—*i.e.*, the rings—which are brought into rubbing contact with the cylinder. These are generally made parallel or bevelled; they are invariably packed behind with greased gasket, india-rubber, lead, or with patent packing, for the purpose of pressing them against the cylinder, or to make them steam-tight. Goodfellow's bevelled rings, fitting between flanges of piston, with a narrow wedge-like ring behind, are sometimes used; also Ramsbottom's small square rings, which are fitted into the periphery of the piston. Some use Stephenson's method, consisting of rings with steel springs, and bolts for tightening; others adopt segments with wedges. These and various other methods have been applied from time to time for producing continuous steam-tight pistons, but hitherto without success. Having briefly described a few of the varieties of pistons in use, which may be classified under two heads, viz., packed and spring, I will now point out the disadvantages attached to each. Packed pistons are those which are packed with gasket, etc. They continue steam-tight for a very short period only, and even when in that state produce enormous friction, so much so that the engine is deprived of much of its power. The friction is also the same in the "outdoor" as in the "indoor" part of the stroke; this is unnecessary, for the piston is not required to be steam-tight in going the "outdoor" part. Spring pistons are those which are provided with steel springs, bolts, wedges, etc. They quickly (through wear and tear, heat, etc.) lose their elasticity, producing results precisely the same as in packed pistons. The steam in escaping is not only a loss of power in itself, but on its escape to the other side of the piston, which is open to the condenser, partially destroys the vacuum.

The following may be taken as showing the principal disadvantages attached to pistons now in use: First, when steam-tight, increased friction from being newly packed, and unnecessary friction when going the outdoor part of the stroke. Second, steam, in escaping, is a loss of power in itself. Third, in its escape it considerably decreases the vacuum, which is also a loss of power; and, last, the great expense of labor and materials, etc., in packing, with the necessary delays occasioned therefrom.

It is an admitted fact by all engineers who have at all considered the matter that the Cornish pumping or single-acting engine is capable of developing a far greater amount of duty than any other class of engine when under similar conditions; and it is with the view of an increased development of power in this type of engine that I suggest the introduction of

steam-tightening pistons. The good results obtained from trials made, prove that the great advantages they possess result from the principle on which they are constructed, and I feel assured that a trial only is necessary to convince any one of their superiority over the present method. Steam-tightening has been adopted for many years past for locomotive and other small engines, but from the imperfect method of admitting the steam, and defective construction of the piston and rings, they have in most cases been abandoned.

The forms of piston I propose for single-acting pumping engines are in Figs. 1 and 2 in accompanying engraving. Fig. 1 is

FIG. 1.

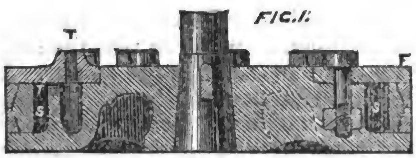
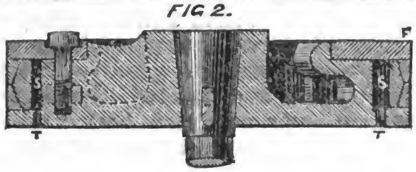


FIG 2.



for a piston where steam is admitted on top, as for the ordinary single-acting pumping engine. Fig. 2 is for a piston where steam is admitted under, for single-acting of the inverted type.

The piston may be described thus:—The form of the body does not vary much from those now in use, and may be fitted to the rod in precisely the same manner. The difference is in the rings, which are three in number, and are well fitted to each other, ground and scraped to flange of piston, and to lugg ring. To allow for the wear of the outer rings, the inner one is made a little larger in diameter, and a piece is cut out of its circumference to make it fit at the back of outside rings; a spaces S (a little larger than that which is generally allowed for packing in packed pistons) is provided for steam, which is admitted through holes T, arranged as in Figs. 1 and 2. By this arrangement, when steaming, a continual pressure, equal to the working pressure, acts against the inner surfaces of the inside ring F, which presses the others against the cylinder in such a manner as to effectually prevent any escape of steam from one side of the piston to the other.

The advantages gained by the above piston over that of the ordinary construction are:—Economy in fuel; increased power from less friction (for when in equilibrium the latter would be very trifling); the saving of steam that would otherwise escape, thereby increasing the vacuum; effecting a great saving in labor, and materials for packing, and also in preventing delays. Seventy-five per cent. of the old pistons could be easily converted into steam-tightening on this principle, and at a very trifling expense.

Referring, secondly, to pistons for double-acting engines. Those generally used are, as before described, for single-acting engines, and any advantages with

FIG. 3.

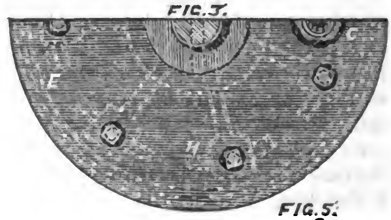
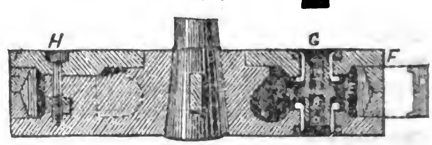


FIG. 5.

FIG. 4.



regard to increase of power and economy in fuel which may be derived from steam-tightening in that type of engine would be double when applied to engines of this class. The method for admitting steam behind the rings, as shown in Figs. 1 and 2, would necessitate the piston being provided with two sets of steam-tightening rings, one for each side of the piston, also with two lugg rings, with bolts, nuts, etc., and then only one set of rings would be steam-tightening at the same time, the other being drawn inward by vacuum, when from one side or the other a continuous rattling of the rings would ensue, thus producing the following objections for steam-tightening the pistons of double engines, on the principle of those for single-acting:—First, the piston would be required more than twice the depth it need be. Second, the continuous noise

consequent from rings being acted on alternately by steam and vacuum.

To obviate these objections, and to use only one set of rings, I have designed a piston as seen at Fig. 3 in the accompanying engraving, and for which letters patent have been granted.

These figures represent a half plan and a vertical section of the piston of a 36-inch horizontal condensing engine, which has been working for the last six months night and day (Sundays excepted), effecting a saving in fuel quite 15 per cent., with 10 per cent. additional power. The cylinder was opened a few days since merely for inspection of piston, and, to my great satisfaction, scarcely the slightest amount of wear was discovered, either in valve or rings, it being steam-tight in all parts of the stroke. The vacuum has been improving from its commencement, and may now be considered as almost perfect; this has arisen no doubt from the rings and cylinder becoming better fitted to each other.

The invention consists in the introduction of a valve, C, in the body of the piston having chambers, B, formed in its interior at each end. Around the sides or walls of these chambers, and communicating with the interior of the piston, are any convenient number of ports or openings, D. These, as the valve is forced to and fro alternately, communicate with the interior of the piston, E, allowing the steam to press or tighten the rings, F, against the the sides of the cylinder. H are bolts for securing the lugg ring. To prevent "blowing through" while the valve is in motion, the port-holes are so constructed that one side will have closed before the opposite one opens. The valve or valves may be made either single or double, and placed opposite to each other, or otherwise, as may be found most convenient.

The advantages gained by this invention comprise the following: the economizing the entire cost of the springs, bolts, and nuts in the construction of ordinary spring pistons, aud with the common packing with yarn, vulcanized india-rubber, and lead. There will be a great saving also in labor and fuel, prevention of delays in opening cylinders, etc., and the loss of power to the engine on account of the springs, rings, and packing losing their elasticity.

After reading the paper, Mr. Pearce remarked that he could bear testimony to the efficiency of the new description of pistons, having seen them in engines at Swansea.

THE SPIRAL PUMP.

From "Engineering."

It is with much pleasure we notice the great improvements Mr. Airy has just made in a hydraulic machine of a very remarkable character, hitherto but little understood. Although the spiral pump—as Mr. Airy states at the outset of his valuable little work on the subject now under review—"was invented more than a century ago by Andreas Wirz, the tin worker of Zurich, and was afterwards made the subject of theoretical investigation by Bernoulli and Eylelwein, and in spite of the unqualified approbation bestowed upon it by all who have studied its action, the machine has been practically ignored, and as a consequence it has not received that attention to mechanical details which so greatly tends to the improvement of a machine; indeed it does not appear that more than four working specimens have ever been constructed." The reason why so little progress has hitherto been made in the improvement of the machine is, in the opinion of the author, due to the rudeness of its construction, and we venture to add—what Mr. Airy's modesty would not allow him to do—to the very complicated nature of the theoretical investigation involved in the action of fluids moving through spiral channels, a subject Mr. Airy has evidently thoroughly investigated and made himself master of. It is gratifying, indeed, to observe that the author in dealing with this subject is able to bring to bear upon it, not only the attainments of a high order of mathematical knowledge, which, as the son of the Astronomer Royal, we might perhaps naturally look for, but that thorough practical knowledge of mechanics, which we know Mr. Airy has acquired—in the only way it can be properly acquired—by going

through the usual apprenticeship of the workshops.

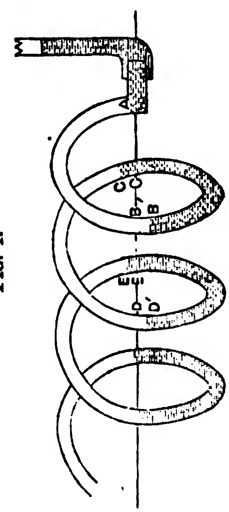
In addition to the causes just referred to, as operating against the more general use of the spiral pump, may be added the great irregularity which has hitherto attended its working, arising from the discharge of both air and water through the vertical pipe, and the difficulty of making good the water-tight joint. Both these difficulties have, it will be seen, been successfully overcome by Mr. Airy; in the first place by the addition of a separate chamber to receive the alternate discharges of air and water through the spiral coil; and secondly, by the simple and ingenious form of leather joint he has adopted. By these means, and by carefully investigating the theory of the principles involved in its action, in which he has been materially assisted in his preliminary investigations by the use of a model with glass coils, the author has converted what has hitherto been but of little practical utility, into a highly effective hydraulic machine, capable of raising water to great elevations; and, under many circumstances, where there is an abundance of water supply even of a very low fall, it is easy to see that it is capable of most useful and economical application.

The following extracts and illustrations will enable our readers readily to understand the principle upon which these improved spiral pumps are worked; but for a great deal of other very interesting and valuable information in regard to it, we would refer them to the work itself: *

The spiral pump is constructed as follows: A metal pipe is coiled round a cylindrical or conical drum, which is placed with its axis horizontal; this drum is carried by means of two axial pivots—one, a solid gudgeon, running in fixed blocks, and carrying on its end a crank, by means of which the drum can be turned; the other, a strong pipe leading into the curved end of an upright pipe, in which it turns by means of a water-tight joint; one end of the metal pipe on the drum is left open, while the other end is led into the side of the horizontal pipe gudgeon above described, and soldered to it at the joint.

If the above machine be erected at the surface of a reservoir of water, and so placed that the drum is more or less immersed; then, as the drum is turned, the open end of the pipe that is coiled on the drum takes in a portion of air and a portion of water at every revolution; and when the drum has been turned as many times as there are coils of the pipe upon it, then the pipe on the drum is full of these fluids in regular order, the water in each coil lying at the bottom of the coil, and the air at the top (the quantity of each depending upon the depth of immersion of the drum). If now the drum be still turned, the water and air in the last coil are discharged into the horizontal pipe gudgeon of the machine, and by it into the vertical pipe; and at every additional turn of the drum an additional discharge of air and water takes place into

Fig. 1.



the vertical pipe; the air at once rises to the surface and escapes, but the water remains in the vertical pipe, and establishes a column of fluid, which is supported as follows:

Suppose that all the coils of the machine have been filled as above described, and that at the next turn of the drum, water will be discharged into the vertical pipe; also suppose that the drum is cylindrical, and is immersed to half its depth in the reservoir, so that the quantities of air and water in each coil are equal, then the position of the fluids will be as shown in Fig. 1; the drum has received the additional turn, and a charge of water has been delivered into the vertical pipe, in consequence of which the water has risen in

* The Spiral Pump, applied as a Force Pump, etc., by W. Airy, B. A., etc. Willis, Southeran & Co., London.

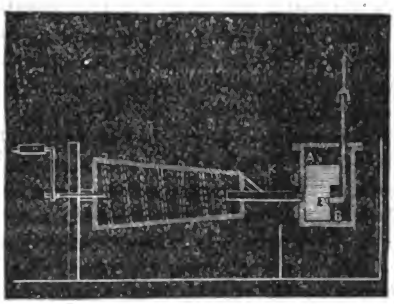
that pipe, and a pressure column is established. The pressure of this column acting upon the surface of the air at A, and transmitting its pressure by means of the air in A B to the surface of the water at B, tilts up the column of water, B C, so as to make it assume the position B′ C′, and thus establishes a small column of water (equal to the difference of level of B′ and C′) tending to balance the water column in the vertical pipe. At the same time the water column, B′ C′, transmits the pressure (lessened, however, by the portion which it carries itself) by means of the air in C′ D to the water surface in the next coil at D, and the water column in this coil in like manner is tilted up into the position D′ E′, and supports a portion of the column in the vertical pipe; and the same is repeated in all the coils on the drum. These operations must not, however, be understood to follow one another in sequence, but all take place simultaneously; the water column in every coil is tilted up a little, that nearest to the vertical pipe being tilted most, and that nearest to the in-take mouth least; and the sum of the columns of support thus gained in the coils of the pipe is equal to the column in the vertical pipe; and thus equilibrium is maintained.

Let now the drum be further turned. Then more water is discharged into the vertical pipe, and a higher column has to be supported; and, as above described, each of the water columns in the coils will be further tilted up, the coil nearest the vertical pipe taking the greatest share of this additional tilting, and the coil nearest to the in-take mouth the least. Since, then, the water column in the coil nearest to the vertical pipe, receives always the largest share of the work of support, it is clear that the upper surface of this column will always stand higher than that of any other of the columns; and in the progress of turning it will at last arrive at the top of its coil.

If, now, the drum be further turned, the water in the last coil being incapable of doing more towards the work of support, will simply overflow into the coil next behind it, and the columns in the succeeding coils will arrange themselves (as above described), to support the additional column in the vertical pipe. In due course of time the upper surface of the water column in the last coil but one will arrive at the top of the coil; and then this column also is performing its maximum duty, and, on the machine being further turned, overflows into the coil behind it. In this way the columns in all the coils are in succession brought to their position of maximum duty, the column in the vertical pipe constantly mounting higher and higher; and finally, when the columns in all the coils are working at their maximum duty, the machine is lifting to the greatest height which it can accomplish. If, now, the drum be turned the water is delivered backwards by the above-mentioned system of overflow throughout the coils just as fast as it is discharged into the vertical pipe, and no increment of height is attained. * * *

Thus far it has been assumed that the air and water are both discharged immediately into the vertical pipe; and it is in this way that all the working pumps of this kind have been constructed. But there is great inconvenience in allowing air and water to go up the same pipe; the water is discharged irregularly, with noise and shocks, and is charged with air-bubbles. Also there is special inconvenience in making the water-tight joint (the only joint in the whole machine), in the curved end of the vertical pipe. To remedy these evils, the author devised the arrangement exhibited in Fig. 2, by means of which the

FIG. 2.



machine has been made to work with remarkable uniformity and success. A B is an air-tight box, and the pipe-gudgeon, C D, is led into the side of A B by a water-tight joint. This joint is simple and exceedingly tight; it is merely a single thickness of leather, in which a hole is cut somewhat smaller than the pipe; the leather being secured to the outside of the box, as shown in the figure, the end of the pipe is forced through the hole in the leather, which thus is somewhat coned,

and its edge wraps close against the pipe; the pressure of the water acting on the side of this leather cone always tends to secure the joint, which is so tight that it does not let through a drop of water; in this joint the pipe turns with very little friction, compared with that of a stuffing-box. E F is the vertical pipe; its lower end is bell-mouthed, to avoid loss of head by contraction of the fluid, and it is stepped on a block at the bottom of the box; at the top is a spout to deliver the water. K is a tap, the object of which will be soon described.

Suppose the tap, K, closed; then, as the drum is turned, air and water are poured into the box; the air, as fast as it enters, ascends to the top of the box, while the water remains below, and is forced up the vertical pipe, as already described.

In this state, the air is of great value, as the upper part of the box then forms an air-chest (as in a fire-engine), and the expansive force of the air, under pressure, insures a regular and even flow of water from the spout at the top of the vertical pipe.

It thus appears that the height to which these machines can force water is determinable simply by the number and size of the coils. The author next proceeds to show how the maximum effect varies in the proportion in which the air and water are alternately taken in at the mouth of the coil, and how the conical form of drum is preferable to the cylindrical in counteracting the prejudicial effects due to the compression of the air in the coils; the singular phenomenon of regurgitation is then noticed and explained. The adaptation of the horn to the intake-mouth, as originally applied by Wirz, the inventor, is then considered by the author, and also the curious effect it has on the arrangement of air and water in the coils.

Before referring to the subject of the general application of this machine, we would say a word in regard to a very ingenious and beautiful application of this principle of the spiral pump, the invention of the author's brother, Mr. H. Airy. In this machine, which is appropriately called a mercury pump, that fluid is substituted for the air, and plays a very important function in its action. Owing to its much greater specific gravity, the mercury column only needs to be $\frac{1}{13}$ of the height of the water column, and the description of the machine very clearly shows how ingeniously, by means of a very small quantity of mercury, which is made to circulate through the coils, a continued stream of water is lifted to a very considerable height. The use of such a machine is of course but of limited application; but for hall and garden fountains, and small fancy jets of perfumed water, etc., no more suitable and effective machine could be desired.

With regard to the advantages of the spiral pump, and the scope for its useful application, we cannot do better than conclude our notice with the well-put observations of the author himself on this subject:

"The advantages of it are numerous and important. Its chief recommendation lies in the simplicity of its action, and the fewness of its parts; there are no sliding valves or other moving pieces liable to expensive repairs, and the one water-tight joint is simple, safe, and easily renewed without skilled labor. The friction may be reduced to a very small amount, for since the drum is always more or less immersed, it will be proper to make the drum hollow and water-tight, so that by proper adjustment of its size, weight, etc., it shall float in the reservoir without bearing at all on the gudgeons. The friction of the water in the pipes is of course unavoidable, but except the velocity of rotation be very great (and this will not be advisable in any case), the friction will not be very considerable.

"The application of the machine would seem chiefly to lie in the lifting of moderate quantities of water to a considerable height, as, for example, the supply of water for domestic purposes from a stream or spring at a considerable distance below the dwellings to be supplied; if there is any fall of water, the machine could be conveniently driven by water-power, and with far greater economy than the hydraulic ram. In such a position its value would be peculiarly felt, as the stoppage of house supply is exceedingly objectionable, and this machine could scarcely anyhow get out of order except at the water-tight joint, which is renewed in a few minutes."

PARIS makes little watches no bigger than a three-cent piece, but the price is $200.

THE ASPHALTE MINES AND WORKS OF PYRIMONT, SAVOY.

From "The Practical Mechanic's Journal."

It is not a little curious how little is commonly known in Great Britain of the asphalte industry of France—one thought so important abroad, and to which we are indebted for whatever asphalte is employed by engineers or architects in our own country. It is equally remarkable how much more largely and universally asphalte is employed on the Continent than it is with us; though there, as here, it competes with artificial—so-called—asphalte, made from coal-tar or its distillation educts, mixed with sand, clay, lime, etc. Chemically, this artificial asphalte may not quite improperly take its title, but its physical properties as a cement or a covering are very different from those of the natural asphalte, and, in certain respects, very inferior.

For mere water-staunch coverings there is no question but that the coal-tar asphalte may, by proper management, be made to answer perfectly; and even as a covering for foot-ways, the experience of many of the *trottoirs* of Paris proves that in skilled and careful hands it can be so laid as to be moderately resistant of strong sun heat, and perfectly so of moisture, and, therefore, of frost.

But even when laid with the utmost skill, it *does* more or less soften with the sun, and the foot leaves its impression if the surface be stood upon without motion for a few seconds. Whilst badly prepared —*i. e.*, with any excess of coal-tar—or with the earthy material badly diffused and incorporated, foot-ways of this artificial asphalte get perfectly sticky, and even half liquid here and there; and "blow-holes" of vapor of some volatile coal-oils open here and there, which afterwards permit the entrance of water, and the next hard frost splits up more or less the adjacent surface. No more valuable or suitable use for this artificial asphalte has been indicated than that so largely found for it in Manchester and Liverpool, *i. e.*, for the cementing together of granite pavement for the streets. It is strange that this employment for it has been so little noticed in London, where we would commend its extension. This great difference between the physical properties as a constructive material of the artificial asphalte, and the natural asphalte of Seyssel or Pyrimont, arises really not so much, if at all, from any differences in the chemical properties of the bituminous matter in each respectively, as to the *state in which* it is combined by mixture with the solid matters in the two cases.

Natural asphalte, more or less like that of Seyssel and Pyrimont, is found in many parts of the world, and in rocks of several different ages or formations, but most usually the rock in which the asphaltic beds are found is calcareous. It is so at Seyssel and Pyrimont; the mines at which places, on the right bank of the Rhone, between Bellegarde (the frontier fortress of France) and Culoz, about an hour and a-half by rail from Geneva, are situated in the Jura limestone.

When the Pyrimont station is reached, close to the grand sweeping current of the united Arve and Rhone, the asphalte works of Pyrimont, the property of Monsieur de Malo, are seen close to the river brink, and a short but steep walk, after crossing the railway, brings us up to the nearest of the many asphalte workings which supply the works. Asphalte is brought to them also from more distant parts of Savoy (still in the Jurassic limestone formation, or in the "Molasse") by barges across and a little down the river, as also to Seyssel, which is a few miles lower down the Rhone upon the same bank, and whose natural mineral riches and manufactured material are identical almost with those of Pyrimont.

The land here slopes rapidly from a sort of rolling and rather inclined mountain table to the south-east of the Jura chain, and from 400 to 600 ft. above the Rhone, down to the river's brink. Climbing about 300 ft. up this steep from the railway, we arrive at the first excavated face of rock, from out of which the asphalte has been extracted, and from which much more remains to be got out. There are horizontal galleries lower down, nearly on the level of the rails, from which asphalte is also obtained, the beds to which these lead being deeper in the rock.

The asphalte-bearing bed (at the upper workings, which are partly open to the

day—a sort of quarry of limited height, with the heavy cap of covering rock not removed) is from 5 to 8 or 10 ft. in thickness, nearly continuous, but very irregular, both in thickness, richness, and form, and, commonly, with very ill-defined boundaries, at the upper or roof side of the seam at least.

The formation of calcareous rock, known as the Jurassic, from the characteristic they afford of the material of the irregular range of mountain stretching along to the north and north-west of the Lake of Geneva, and called *in globo* the Jura—though one long mountain alone, properly bears that name—consists of a vast variety of calcareous materials, from incoherent marls and hard limestones of nearly pure carbonate of lime, to sandy marls and limestones, loose sands with more or less calcareous dust or mud mixed, and liassic limestones of variable hardness, but often very hard, and containing variable proportions of alumina, magnesia, and silica (in a soluble form), which produce in certain beds admirable hydraulic limes. These various qualities of limestone are in many places found mixed up together in a sort of discontinuous stratification, and in the most irregular way and forms; such is very much the case at these Pyrimont mines.

The main mass of the rock exposed is of very variable petrological character, yielding more or less fat or non-hydraulic lime when burnt; but it contains, with a rude, irregular sort of discontinuous continuity, three remarkable beds. The middle one of these, the asphalte, is the subject of our notice; above it *generally* (not always) is found a greenish-gray, soft marl, coherent but friable, and below it a seam, of variable thickness, of dense, close, fawn-colored and gray liassic limestone.

The asphalte bed is of dark hue, varying from perfect blackness but without lustre, to a soft gray or yellowish-brown. It is in fact only a bed of porous limestone, very variably but most thoroughly impregnated naturally with bitumen. This latter can be completely washed out from pulverized specimens by means of sulphuret of carbon as a solvent, and the limestone then appears almost as white and soft and fine as powdered chalk. It is, in fact, almost chemically pure carbonate of lime, containing merely a trace of peroxide of iron, and appears to hold the water found in it merely in mechanical suspension.

The asphalte is worked on the plan called in coal-workings "pillar and stall," and is all taken out by blasting, the consumption of powder being, however, very trifling; when detached, its fracture is coarse, and generally earthy; the surface of fracture straight, or tending slightly to conchoidal. It is soft, so that one piece of asphalte leaves a large umber-brown streak when rubbed against the surface of another. It is neither sticky nor unctuous to the hand, but soils strongly, and exhales the peculiar smell which, once recognized, is not easily forgotten.

Occasionally, however, parts of the seam show glistening master joints and cross ones slimed with gluey asphalte; and now and then, though rarely, cavities are found in the rock more or less full of actual liquid asphalte. These indications occur wholly in the harder portions of the seam and in its lower portions.

We cannot in a notice, necessarily here too brief from want of space, enter upon the highly interesting and curious questions, as to the origin in the play of natural forces which have produced this valuable material, further than to say, that probably in every case the permeation of the porous rock has been produced by natural distillation and sublimation of hydro-carbons pre-existing in other states more or less analogous to coal; the distillation having taken place, sealed up by heavy beds of superincumbent rock from access of air, the temperature being low, but the pressure of the evolved vapors, and that under which condensation has occurred, very great. During one of the most recent eruptions, that of 1862–3, of Vesuvius, which breaks through Apennine limestones—lithologically very much of the character of those of Jura—all the wells about Torre del Greco began to exhale the exact smell of Pyrimont asphalte when heated, and traces of bitumen were observed in films upon the surface of the water sources. There can be little doubt that here asphalte was either being formed from beds of lignite, which are frequent in the limestone of Italy, or that beds of asphalte, already so formed, were being exposed to heat and vaporization.

The asphalte as extracted from the Pyrimont mines is passed down to the works by a double inclined tramway, the

surface contour of which in section is a nearly exact parabola, the empty wagons being taken up by the descent of the full ones. The works for its preparation for market also lie upon a rapid slope, and advantage is taken of this form of the ground, so that the raw asphalte arriving first at the highest level passes down by its own gravity, as it also passes through each process, until, arrived at the bottom, it is ready for shipment on the river; that which is to be sent away by rail being hoisted up again, by the steam power of the works, to the level of rails upon a short direct and steep tramway by means of a wire rope.

The asphalte of commerce occurs in two forms: 1st. The natural asphalte merely reduced to a coarse and uniform powder, about the size of mustard seeds, which is employed for laying floors, footways, streets, etc., mixed or not with dry sand, or with sand and lime.

It is simply heated in cauldrons to about 250 degs. Centigrade, spread out upon the prepared base or foundation, and beaten and consolidated with heavy instruments of cast-iron heated *nearly* to low redness.

Laid in this way the asphalte is *nearly* rain-proof, though not so, to even a small head of water, and is, when hardened, solid, firm, and coherent. The preparation at the outset, or first operation, is the same for this and for the second sort of asphalte, viz., that which is sold all over the world in round-shaped flat cakes or blocks, weighing about 100 lbs. each, and which, when to be used, are quite melted up into a thick liquid like pitch, and in that state ladled out upon the prepared floor to the desired thickness, with or without admixture with sand, lime, or other pulverulent matter. In this state the consolidated asphalte is compact, water-tight under any head of water, harder than the former, rather more brittle in extreme cold, and rather softer in great sun heat.

The raw asphalte is powdered in mills driven by power, which requires to be large from the toughness of the material. The mills are of various sorts; edge stones, like those of common corn-mills, and heavy cast-iron sharp-toothed conical hopper mills, like our bark mills, or gigantic coffee-mills. Carr's patent centrifugal quartz-crushing, or rather breaking, machine, is now in process of erection, and about to be tried for smashing up the larger lumps. The writer, however, does not anticipate any great success from its application to this rather tough material. No "stone-breaking machines" of the class now in such frequent use for crushing road metals and ores, etc., are as yet employed.

A large train of lifting machinery, mainly consisting of revolving screens, succeeds the crushing machinery, and are chiefly employed for the asphalte to be laid dry as it is called, *i. e.*, spread in powder. Separated into different finenesses. and qualities, this powder is packed in casks for export.

For the manufacture of the fused cakes but little previous crushing is required. The natural asphalte cannot be melted as it comes from the rock, by any amount of heat applied with ordinary rapidity, without the destruction of a considerable portion of it. Indeed, heated *dry* it takes fire after evolving much gray-blue smoke of asphaltic vapor, long before it shows any signs of melting or even of softening.

The process, therefore, by which it is rendered a viscid liquid, is a double one, dependent partly on solution, partly on fusion, or perhaps it would be more correct to say that it is simply fusion aided by heat. The solvent employed is not the product of the Seyssel or Pyrimont mines, and is brought to the works from so distant a point as from near Autun, in France. At Autun there is a vast manufacture of shale or schist oils, *i.e.* of various more or less volatile hydro-carbons, applied to several purposes in the arts as well as to illumination, procured by distillation from bituminous *shales* or *schists*, after the methods first successfully employed, if not first pointed out, by M. Selligues. In the refinement by fractional distillations of these crude shale oils, there remains a large amount of a peculiar viscid, but at any ordinary temperature more or less liquid, dark-colored, and peculiar-smelling *shale or schist tar*.

This is the solvent employed for the Pyrimont asphalte. It is brought in casks (iron tank wagons would be much better) by rail, and at once started into a huge masonry tank for storage at the upper part of the works; this is covered from rain.

Into deep rectangular boilers, each

about 3 metres long, 1 or 1.2 metres wide, and 2 deep, is put a certain quantity of this schist tar; a gentle heat is applied direct by coal fire to the whole range of these boilers, and when the tar boils slowly, an equal volume of the raw asphalte, in powder or small lumps (just as it comes), is added; the heat is maintained for 12 hours, and at the end of that time the whole of the asphalte is found to have bcen dissolved and combined with the tar.

From the heterogeneous nature of the natural asphalte, however, as already described, many nodules, or portions of finer divided matter, do not dissolve at all, but remain incoherent in the bottom. This is little more than mere limestone, though penetrated, or, at least, colored by asphalte, and externally black and covered with tar.

The boilers have perforated false bottoms, and cocks and mains by which, at this stage, the thick liquid matter is racked off from the undissolved residue, and is passed directly down below, without cooling, into another very large rectangular cauldron, in which the produce of the whole range above gets united. This is kept warm by coal fire heat. Out of this the now formed asphalte is laded by hand, by men naked to the waist, and put into buckets which hold just the right quantity. These are carried away by other gangs of equally stripped men, who fill out of these buckets the wrought-iron moulds, ranged upon the floor, in which the cakes of asphalte set hard, and removed from which they are ready for market.

The liquid asphalte is not to the eye even, a homogeneous fluid; it looks, though at a low temperature in comparison, almost exactly like liquid trachytic, or certain basic sorts of lavas, which consist of a glossy slag, filled full of less fusible crystals, all flowing along together accordingly; except that it is intensely black and shining, this liquid asphalte looks very like very coarse oatmeal porridge, in which the grains of large meal are still quite discernible.

Each mould consists of a ring in two segments, each formed of flat bar-iron about 6 ins. wide by ¾ in. thickness. To one of these inside is riveted a cast-iron plate with the name of the maker (Malo, Pyrimont) in relief upon it, so that the cake, when hard, shows this trade-mark in *intaglio*. The floor is of cast-iron plates, kept smeared with white clay and water, with which also the moulds are constantly kept coated. They simply lie upon the floor, and the two segments are heavy enough not to separate when filled. The buckets are, though kept hot, dipped into water each run, so that the asphalte parts cleanly from them. The filling and emptying goes on rapidly, so that eight men do the entire work of moulding of the concern, the machinery of which occupies an engine of 35-horse nominal power.

The men are powerful, but the labor is obviously severe, and not free from occasional danger of a burn. Besides the asphalte of his own mines, Monsieur de Malo now works up a large quantity of bitumen or asphalte from the Pitch Lake of Trinidad, which is at present imported largely into Marseilles.

It is to be regretted that our own manufacturers and organic chemists have as yet all but ignored that exhaustless source of bitumens of several sorts; the more so as one of the most recent discoveries announced in the limitless field of organic chemistry is the production of *artificial alizarine* (a substitute for madder), from *anthracene* (paranaptaline), obtained by acting upon these very asphaltes of the Jura; and that the Pitch Lake of Trinidad may yet be one of the greatest sources of coloring matter for the whole world, needs no stretch of imagination to foresee. As yet, neither at Pyrimont nor at Seyssel have any attempts been made to obtain any other products from the natural asphalte than we have above described; perhaps a not unnatural consequence of a well-paying trade, which nature herself has made almost a monoply.

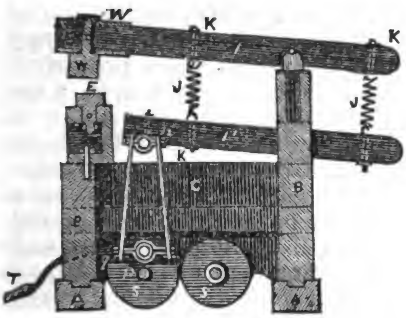
KOURIE CEMENT.—A new gum has been introduced to the trade, obtained from trees in New Zealand; it is called "kourie," and has found to be a most excellent, strong, and water-proof cement for calking tanks and cementing pieces of glass, stone, or wood together. Before using, it is fused or mixed with one-third part of its weight of castor-oil.

DR. TSCHUDI in his "Travels in Peru," says of Lima, that, at an average, 45 shocks of earthquake may be counted on in the year.

OPERATING TILT HAMMERS.

From "The Mechanics' Magazine."

Mr. T. T. Prosser, of Chicago, has invented the method of communicating power to tilt hammers shown in the accompanying cut. His invention also relates to the arrangement for hanging, operating, and controlling the hammer, and the changing of the hammer dies both in the hammer head and in the anvil. The invention has recently been patented in England. Our engraving shows a vertical longitudinal section of the apparatus.



A A are two sills which form the base of the machine frame; B B are two posts inserted in the sills to receive the balance of the timbers composing the frame. Bolted on each side of the posts B are two longitudinal pieces C forming the side timbers. The rear post is longer than the front one, so as to receive the cap or cross piece D on its upper end. By thus arranging the frame all parts are in position to receive the working parts of the machine, and form a durable and perfect arrrangement. On the upper end of the front post is the anvil block F, containing the die E, which is made adjustable and is easily removed. Upon the upper and lower side of each end of the cross piece D are fulcrum or pivot boxes G to receive the pivots H passing through the vibrating arms I and I^1, which are connected together and held in position by the springs J and bolts K. The arms I I^1 are in pairs, and the lower pair of arms is shorter than the upper pair; and the arms are in each pair much further apart at the rear end than at the other or front end; the rear ends of each pair are not connected, whilst the front ends are. The lower pair of arms is connected at the front end by a pin *l* and the bolts *m*. In the middle of the pin *l* is a box *n*, to which are attached the eccentric rods that vibrate the arms I^1 and I by means of the eccentric O on the shaft P, which is connected to the short arm of the levers *q*, which are pivoted at R, and, as the eccentric is driven by the friction wheels S, it will be evident that as the foot is placed on the footboard T the shaft P will vibrate and bring the wheels in contact with those driven by the belt *u*. As the pressure of the foot causes an increase of friction, the vibrations correspond therewith. As the hammer is moved up and down by these vibrations, the faster the vibrations are the harder the hammer will strike, and the slower they are the slighter blow the hammer will strike. As these motions are under the control of the operator by means of the footboard T and lever *q*, the machine can be made to strike just such a blow as the operator may desire.

The upper pair of arms are longer than the lower arms, and their front ends are permanently attached together by means of two plates *w*, through which the hammer shank passes, and to which it is attached by the nut V on the upper end of the hammer shank. The hammer shank near the hammer W is square, and the hole in the plate on the under side of the arms through which it passes is made to correspond therewith, whilst the hole in the upper plate is round. The object of making the hole and hammer shank square is to keep the hammer from turning. By connecting the lower arms to the upper by means of the springs, the inertia of the hammer when at rest and the recoil when at work are overcome in such a manner as to relieve the machine from those violent shocks incidental to the common tilt hammer and to convert them into useful effect; for as the hammer is thrown up by its momentum to a greater distance than the movement of the eccentric, an increased amount of tension is imparted to the forward springs; and when the hammer descends, the increased tension causes it to descend with increased velocity and additional force, thus being enabled to strike a much quicker and harder blow than can be done by the machines now in

use. As the springs admit of a ready adjustment by means of the bolts and nuts, it can be readily adjusted to a rapid or slow motion as desired, and as the shock consequent upon a vibrating motion caused by a reverse movement is all taken up by the springs, its motions are all easy, and it cannot fail to be durable, the importance of which advantages must be evident to all who are acquainted with the vast amount of labor performed by this class of machines.

HINTS ON HYDRAULIC JOINTS.

From "The Engineer."

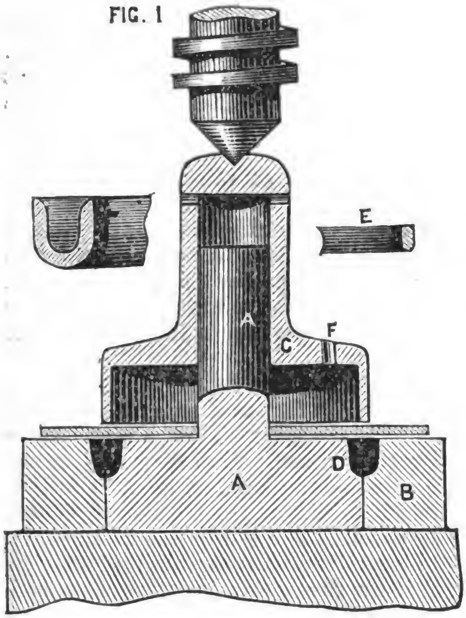
Extensive as the present application of hydraulic power undoubtedly is, there is no reason why it should not be much more so if two causes of retardation were removed. The first of these is, that the extreme adaptability of hydraulic pressure to many operations requiring but little power is as yet not understood. For instance, in very many cases a steady and perfectly smooth motion, such as can be regulated to any speed, and also so arranged that the power cannot rise above a certain point, would be invaluable for small manufacturing purposes. Now, if, as is generally the case, a screw, cam, or other ordinary mechanical means be used, the gradation of speed—though simple enough in its first design—offers a difficulty in general when the apparatus is in motion. Further, should any obstruction occur, the power at once begins to accumulate, till in many cases the force becomes so great as to cause the destruction of some part of the apparatus or of the article being operated on. The practically perfect non-elasticity of water gives just the advantages required. A motion of complete uniformity can be obtained; it can, without stopping the operation of the apparatus, be regulated to any desired extent, from *nil* to the most rapid motion originally provided for in the designing of the machine. Should the resistance be increased by any obstructions the machine will simply stop, instead of destroying any part of itself or the material on which it is acting, supposing always that ordinary care and knowledge are exercised in proportioning the work, pressure, and size of the machine to each other, and the ultimate power to the ultimate resistance. But it may be objected that hydraulic power is only applicable where very great resistances have to be dealt with, and that it is not at all applicable where very small degrees of power are required. Again, it may be said that there is so much trouble with the joints as to render other appliances preferable. With this question of hydraulic joints—why they give so much trouble, how they ought to be made, and what amount of endurance may be expected from them when properly constructed, we propose to deal in a simple and practical manner, leaving the other questions we have opened, for a future occasion. To all intents and purposes the joints, more particularly the working ones, are the vital parts of any arrangement of hydraulic tools. No matter how correctly the other parts of the apparatus may be designed, if the joints be defective continued annoyance will assuredly ensue. How to make really effective hydraulic joints is a secret possessed by but few, those generally made being simply barbarisms, and nothing more. No matter how well the leathers are made, or of what quality of material; no matter how carefully they are inserted, or how correctly the recesses for them are shaped, if they are called upon to encounter anything but a highly polished surface against which to work, they cannot last long. It must be borne in mind that if an unpolished surface is conducive, in the case of a metallic packing moving in contact with it, to rapid wear, it is, in the case of leather, nothing short of positive destruction. In the case of leathers under high pressures, the very specks in the metal become so many traps into which the leather is forced by the pressure, only to be rapidly torn away in small fragments. It might seem trite and unecessary to urge this truth, were it not that we have before us but too many cases where most costly results have followed from the use of unpolished or specked surfaces. Over and beyond these causes there is still another, which is, we might almost say, universal, so seldom is care taken to avoid it, or rather, in

fact, so deliberately is it, as it were, cultivated. We refer to the rapid destruction of the leathers by reason of the destructive mode of insertion in recesses formed only with a view to, first, cheapness, in such a way as to positively insure the actual cutting of the leather. In making hydraulic joints three types of leathers are used, which may be classed as cup, cap, and hat leathers respectively. The cup leather is the most commonly used, and is of a form so well known as not to need any description here; the cap leather is like a hat deprived of its brim, and with a hole in the crown; the hat leather is exactly like a hat with a brim but no crown. Of course in each case the grain of the leather, that is, its outer side, must form the working surface of the hydraulic packing. It will then work to a smooth, evenly polished surface, if proper care be exercised in the finishing the metal work in contact with it. We have found considerable benefit to arise from the use of the anti-attrition powder of Messrs. Morgan Brothers, when applied with a little of the best unsalted tallow as a lubricating paste to the leathers. For the proper preparation of hydraulic leathers of various kinds, the following mode of procedure will be found completely successful. The leather selected must be the best English tannage, that is, oak-bark tanned leather. The suitable portions of leather are the hard parts of the butt for large leathers, and the best shoulders for small ones; on no account should any of the belly leather be used. With a sharp knife the whole of the fleshing, or soft inner portions, must be completely removed, great care being taken to cut the leather to a very even surface. The slighest cut below the surface will spoil the part so cut, as the leather when at work will there fail, and that soon. Having so prepared the inner side of the leather, the grain or outer side must be turned uppermost, and very carefully examined for any cuts or flaws, no matter how minute. With a pair of dividers the circles describing washers of the sizes suited to produce the required leathers, must next be drawn in. For cup and hat leathers, an inner circle will be requisite to mark the piece to be cut out at the centre. When cap leathers are required without any hole in the crown, the leg of the dividers must not puncture the centre of each washer. In this case either place a loose bit of leather, to take a centre from, or use a circular templet, and "scribe" round it. When the washers are cut they must be overhauled, to see whether the thickness is exactly equal all over each. If it be not made so, the leathers will draw unequally in the dies. The best way to make the washers is to cut squares of leather, fasten them by tacks to a piece of wood faced true in a quick lathe, and then turn them, first, to the proper evenness of thickness; secondly, cutting them to the right circular size. Of course the grain side must go towards the wooden face-plate, and the tacks must only pierce the waste corners. After the washers are thus prepared, they are to be steeped in soft water till soft and flexible.

When they have thoroughly softened, they are ready for the dies, which we shall proceed to describe. First, we will show how a really good pair of dies ought to be made for making cup leathers. The best material for dies is good hard gun-metal, as cast-iron is affected by the tannic acid, and so gets very stubborn in its behavior, so that the dies move in and out of each other with considerable friction. Besides, the iron is apt to tear the leather, since it becomes, as it were, adhesive or grating on the surface, so that the leather does not slide easily into the recess of the dies.

In Fig. 1 is shown a pair of dies of the the most improved design for making cup leathers. The figure also includes the proper means of forcing the dies home on the leather. A is the centre piece of the dies, having the projecting spindle Á, which acts as a guide to centre the leather washer and the moulding-ring; B is the outer die, fitting accurately round A. The recess, D, is formed half in each die; when this rule is not observed, there is a difficulty in removing the leathers when finished, and they are very frequently injured. When very large numbers of leathers have to be made, it is worth while to provide special means of removal from the dies. The best means consist of two rings of metal a little deeper than the dies. One ring should just pass freely round the die A, the other through the die B. The edges of these rings must be smooth and rounded. The rings merely lie on the bench beside the operator. When the dies are separated, the leather is

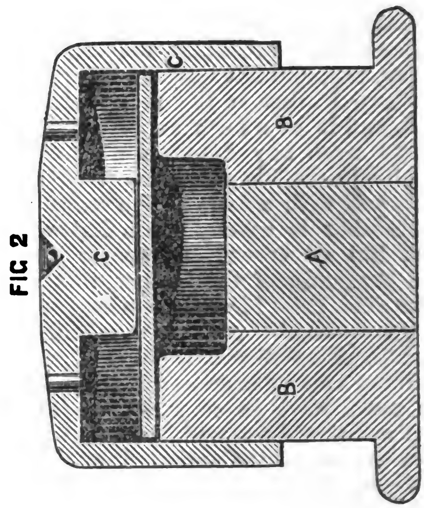
very quickly removed from either die by means of these rings. Should the leather, as is usually the case, be upon the die A, this die is merely dropped into the ring belonging to it. If the die B should



carry the leather, it is forced over the proper ring. If these rings are not provided, some blunt instrument must be used. The bell, C, fitting upon the guide, A, is in every way superior to the ring generally used for forcing the leather into the dies. The small holes at F F, are to let out the air. The arrangement of screw press for forcing home the bell, C, needs no description. The best arrangement of all others for forcing the bell home is hydraulic power itself. When a press is at hand, the leathers are best prepared by placing the dies between the plattens, and then allowing merely a slight opening of the valve to produce just a leakage into the cylinder, by which means a very slow and uniform motion may be produced.

After being forced home into the dies, the leather must be allowed thoroughly to set. When it gets firm, the pressure may be removed and the bell, C, withdrawn. Next insert the ring, E, in place of the bell, C, and with a very sharp knife or chisel, pare the leather off level. If you have no lathe you must finish the leather in the dies to the section shown at G, but if you have a lathe, the leather should be put into a split chuck, and carefully trimmed. The leather should finally be treated with tallow and anti-attrition powder, as stated above.

For making cap leathers the tools shown in Fig. 2 should be used. The plunger die C

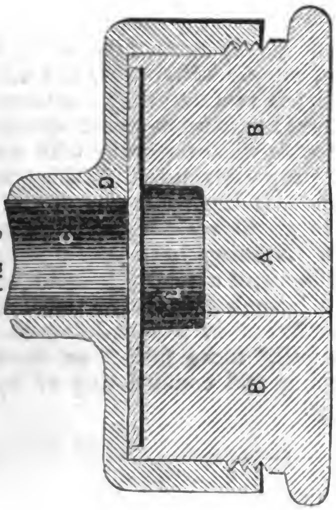


should be forced from the centre as before, or by a pressure applied true with the top. The centre piece A is requisite for facilitating the removal of the leather from the die B. It is necessary to make the die C with a bell guide C, to keep itself and the leather centred with B. When the leather has set, the die C is to be removed, and the plug D being inserted, the leather is to be pared level off. It should, of course, where practicable, be finished in a lathe to the section at E, and in all cases dressed with tallow and anti-attrition powder.

For making hat leathers the arrangement of dies shown in Fig. 3 must be used. The outer die, with its centre-piece, will be easily understood from the descriptions of the other figures. The leather L is, in this case, laid with the grain upwards, as denoted by the thick line, while in the other cases it is placed with the grain downwards. In order to form a flat brim to the leather the holding down cap D is provided to screw on to the die B. It must not hold the leather with excessive tightness, otherwise the ram C will burst the centre of the disc. The upper part of D forms the guide for the ram C. After the leather is set it should be put on to the plug E, and be pared round the edge. The crown should be cut out as at the

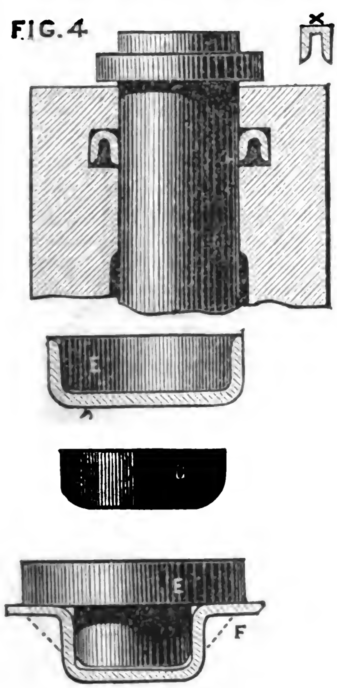
lines F, F. Both these trimmings are, however, better done in the lathe. Leathers thus made cannot fail to give satisfaction. It must be borne in mind that no grease or other sticky material should go

FIG 3



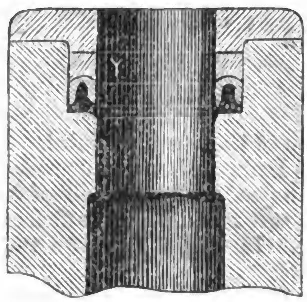
near the leathers till they are just about to be used, otherwise they will collect dust, which is, above all, to be avoided.

FIG. 4



Having made our leathers, we have only to speak about their insertion. As usually inserted (see Fig. 4), the leather is forced through a smaller diameter than its own, into a recess suited for nothing so well as its speedy destruction. Immediately the pressure is put on, the leather is forced into the shape shown at X. The result is, that, instead of wearing equally, it soon cuts through at the sharp corner produced. The proper way to insert a leather is shown at Fig. 5. Here it

FIG 5



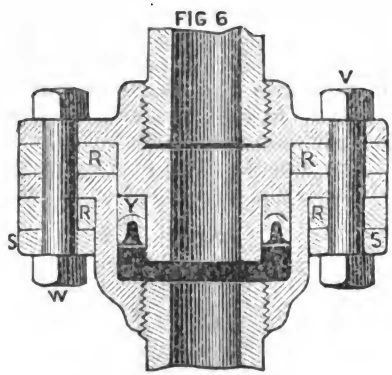
will be seen that the leather is not put through any diameter less than its own. At Y is inserted a loose ring of metal accurately shaped to receive the back of the leather, and to form a bed for it. Thus the leather will preserve its proper shape; no sharp corners will be formed, and, therefore, the leather will really wear gradually away, in place of splitting open or tearing.

So far, we have spoken of the joints suitable for presses, pumps, and accumulators. In each of these cases there is, of course, a sliding motion through the joints. We have now to speak of those joints—in pipes, etc.—where there is no such motion to be provided for. These joints are usually made by screwing up discs of leather or lead between sockets and glands. The surfaces should have slight circular grooves turned in them. Small lengths of copper or brass tube should be put as insertions where the joint is to prevent particles of the packing from being forced into the pipes. In all cases where long lengths of pipe occur, expansion joints should be provided.

These joints should be formed on the spigot and faucet plan, with flanges held together by nuts and bolts. Between the flanges thick rubber washers should be placed, to allow of the expansion and contraction of the pipes.

The joint should be made water-tight

by a cup leather on the spigot and fitting inside the faucet; Fig. 6. shows the con-



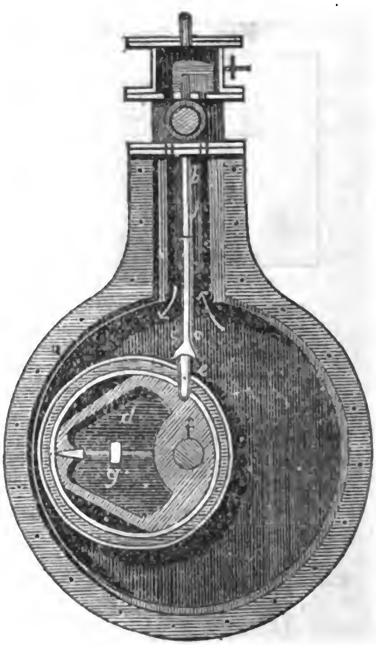
struction of this sort of joint. The ring of metal Y may, when numbers have to be made, be produced by a pair of tools in a press, a soft metal being sufficient for the purpose. In Fig. 6 R, R are the rubber washers, and S a loose flange. The bolts pass through from V to W. It will be seen at a glance that the rubber between the spigot and faucet allows for any compressive action on the joint, while the other rubber accommodates any stretching action.

These joints are easily made, as they are all simple lathe work, and where any quantity is required they can be very rapidly bored and turned with special tools. No trouble will ever occur with a series of joints properly relieved in this way. We have here indicated in detail the correct way to go to work in making hydraulic joints. Nothing here specified is at all superfluous, if a good job is to be made. In no branch of constructive art is the saw, "What is worth doing should be done well," more fully true than in the designing and constructing of hydraulic fittings.

ROTARY ENGINE.

From "The Mechanics' Magazine."

Messrs. Johnson and Gill, of Unstone, Derby, have lately patented some improvements in rotary engines and pumps. In their invention a direct rotary motion is given to the shaft of the engine, the moving parts working perfectly steam-tight with a small amount of friction. When motion is given from an external source to the shaft, the piston will act as a pump for raising or forcing water. The engine consists of a cylinder, secured on a foundation, and having a central shaft working in bearings at each end. On this shaft is mounted a circular piston, revolving eccentrically around and within the cylinder, at the top of which the inlet and exhaust pipes are applied. Between the ports a slot is cut, in which a slide has a reciprocating motion, and which, therefore, separates the exhaust from the feed, the slide also working in grooves cut within each end of the cylinder, and being attached to the piston by a saddle and knuckle joint in connection with a belt surrounding the piston, but not rotating with it. By this arrangement the eccentric motion of the piston causes the slide to ascend and descend at each revolution of the shaft, always maintaining a perfect steam stop. The piston is made in two parts, so as to insure its being steam-tight. The interior contains a spring ad-



justed to any pressure by a screw, to bind or thrust its periphery against the surface

of the cylinder, and the outer ring is divided into two parts, so that it can be sprung to the face of the side. The end also of the outer ring contains a groove, wherein the ring attached to the strap works, which connects the slide to the revolving piston. The strap works through the end of the slide, and is connected also to a spring at the top of the slide to keep it to its work. When used as a pump the chest and feed valve is not required; the feed and exhaust ports serve equally for the inlet and discharge of the water, the engine working in exactly the same manner as when steam is applied.

We show a vertical section of the engine, in which *a* is the end plate or cover of the engine, with the groove *b* cut in it for the reception of the sliding top *c*, attached to the cylindrical piston *d* by means of the jointed strap *e* and loose ring in the centre of the piston; *f* is the shaft to which the piston is fixed, and *g* is the screw rod which forces the piston against the interior of the cylinder; *h* is the feed pipe, and *i* the exhaust ports, the arrows showing the direction of the steam or water and the consequent course of the piston. The slide rises and falls within the groove and within the slot *j* in the upper part of the engine above the main cylinder, being always attached to the ring enclosing the cylindrical piston, so as to acquire a reciprocating vertical motion caused by the eccentric movement of the piston. The engine will be found applicable to driving screw propellers where direct rotary motion is desirable, as it occupies a very small space in comparison with that necessary for a reciprocating engine.

NOTE ON THE EARLIER HISTORY OF THE SCIENCE OF HEAT.

By GEORGE FARRER RODWELL, F. C. S.

From the "Chemical News."

As a supplement to the lectures on "Heat" which have recently appeared in this journal, it will not, I think, be out of place to give a short account of some of the principal facts connected with the earlier history of the science of Heat. In doing this it will be impossible to preserve any great continuity, my object being rather to indicate some of the old scientific treatises in which experiments are detailed, and to supply the student with a means of reference which the foregoing lectures of necessity could not afford. The memoirs and the works of recent writers on Heat are so well known and so much at the command of all who desire to pursue the study, that it will be sufficient to mention the names only of Cazin, Clausius, Despretz, Franz, Guthrie, Helmholtz, Herschell, Hirn, Joule, Knoblauch, Kopp, Magnus, Mayer, Melloni, Pouillet, Regnault, Balfour, Stewart, Tait, Thomson, Tyndall, and Wiedemann.

It is difficult to say when the science of Heat properly, so-called, first arose. It is certainly a younger science than Statics, Dynamics, Hydrostatics, Hydrodynamics, Pneumatics, Optics, Static Electricity, and Magnetism. I question whether Acoustics can be added to this list, although it has ever had the stimulating effect of the art of Music, which, in its turn, had the stimulating effect of Church Ceremonial, and attained some perfection in the 16th century, and much perfection in the 18th. M. Libri very truly says, "Les recherches des Pythagoriciens sur les vibrations des corps sont les plus anciennes expériences de physique qui soient parvenues jusqu'à nous;"* but we must bear in mind that the results of these experiments were applied to Music as an art, rather than to Sound as a science. Omitting, then, the question of the precedence of Acoustics, we yet perceive that Heat is among the younger of the sciences. This arises from the fact that, until late in the last century, heat was regarded as a chemical agent, and became merged more or less into chemistry proper. Separate treatises on Heat were unknown, but every chemical work devoted some chapters to the acts and operations of fire. "Car en effet," as Lemery remarks, "c'est par le moyen du feu qu'on vient à bout de presque toutes les opérations chimiques." Hence arose such expressions as "Chymic heat," "ye hete of ye chimists fornace," etc., to designate intense degrees of heat. Then, again, the theory of Phlogiston is essentially a heat

* "Histoire des Sciences Mathématiques en Italie." 1838.

theory in one sense, but it has ever been regarded as a chemical theory, because the action of heat is so closely associated with the majority of chemical operations that the scientific cared not to step aside to examine the nature of heat itself, preferring to leave the examination of the cause, to study that of the ultimate effect. Boerhaave in his admirable "Elementa Chemiæ," the most extensive chemical work which had up to that time (1732) appeared, devotes a good deal of space to the "instruments" of chemistry, "beginning," as he remarks, "with fire, by reason that no chemical operation ever was, or can be hereafter performed, to which fire does not contribute." (It may be remarked here that *fire* and *heat* were often used as almost synonymous terms by old writers; thus Boerhaave says "Fire expands even the hardest bodies.") I imagine that Francis Bacon's little treatise "De Formâ Calidi," was the first attempt to raise Heat into a separate science. It was an utter failure, yet the attempt is to be applauded, for it was the lack of observation and the paucity and obscurity of the knowledge possessed at that time by the world at large in regard to heat, that of necessity resulted in the failure. What are we to say to such an assertion as the following? "Omnino calor cælestium augetur tribus modis; videlicet ex perpendiculo, ex propinquitate sive perigæo, et ex conjunctione sive consortio stellarum." S. Gravesande in his excellent "Physices Elementa Mathematica"—one of the best illustrated works on Physics which has ever appeared, and which may even now be consulted with advantage—gives 45 pages ("Editio tertia, duplo auctior," 1742) to Heat, and 234 to Light. He commences the "Liber de igne" with the very pertinent remark, in his blunt rugged Latinity, "Pauca de igne norunt philosophi; multa ipsos latent," adding very sensibly (and it is to be wished that his example were more often followed) "Hypotheses non fingam; generaliora, que experimentis deduci posse mihi videntur, eo quo potere meliore ordine, dicam."

The production of fire by the refraction and reflection of the rays of the sun was well known to the ancients. The sacred fire of Vesta was re-kindled by the rays of the sun reflected from a metallic mirror, and, according to Pliny, the mirror was sometimes replaced by a glass globe filled with water. Aristophanes clearly alludes to the use of glass lenses as burning glasses, in the Νεφελαι.

Lactantius, in his curious treatise "De ira Dei," mentions that a glass globe filled with water and placed in the rays of the sun, will kindle fire even in the coldest weather.* Baptista Porta in his ever new, ever interesting treatise, "Magiæ Naturalis"—which links the magic of Art of Eastern civilization with the magic of Nature of Western civilization, Chaldæan mysticism and Theurgy with the Realism of the Renaissance—Baptista Porta mentions the fact that heat, sound, and cold may be reflected by mirrors in the same manner that light is reflected. As a delicate instrument of observation in the case of the reflected cold, Porta placed his eye in the focus of the mirror, as, some two and a half centuries later, Dr. Tyndall placed his eye in a focus of dark heat rays in order to see whether any light accompanied the heat rays. Porta's account is interesting; it occurs in the seventeenth book, and is entitled "Calorem, frigus, et vocem speculo concavo reflectere." "Si quis candela in loco," he continues, "ubi spectabilis res locari debet apposuerit, accedet candela per aerem usque ad oculos, et illos calore et lumine offendet, hoc autem mirabilius erit, ut calor, ita frigus reflectitur, si eo loco nix objiciatur, si oculum tetigerit, quia sensibilis etiam frigus percipiet." Somewhat later Hamerus Poppius calcined antimony "per radios solares" with the use of a lens, in order to determine whence came the gain of weight. Bonaventure Cavalieri, the discoverer of infinitesimals, writing in 1632, states that he was able to inflame dry substances by reflecting the heat emitted by charcoal fire by means of a spherical speculum; by using a parabolic reflector he produced the same effect at a distance of 5 ft., a small fire of wood being the source of heat. He recommends a hyperbolic reflector, and asserts that the impressions of heat, cold, sound, and

* Lactantius was born about A. D. 250; he died in 326. His words were amongst the first printed in Italy; the first edition issued from the press of the monastery of Subiaco as early as the year 1465, while a second issue appeared in Rome in 1468, in both cases it will be remembered before a single book had been printed in this Island. The passage alluded to above is taken from the 10th chapter, entitled "De mundi ortu, et rerum natura, et Dei providentia," and is as follows: "Omitto silicem, ac ferrum. Orbem vitreum plenum aquæ si tenueris in sole, de lumine, quod ab aqua refulget, ignis accenditur etiam in durissimo frigore."

scent move in straight lines.* Athanasius Kircher has also treated of reflection in his "Ars Magna Lucis et Umbræ."

The term "radiant heat" was introduced by Scheele in his treatise entitled "Luft und Feuer." Pictet in his celebrated "Essais Physiques sur le Feu" (1790) demonstrated the enormous velocity of propagation of radiant heat; he also treats of absorption and reflection of heat, and of latent and specific heat. Prevost made known his "Theory of Exchanges" in 1791 through the medium of the "Journal de Physique."

Black discovered "latent heat" about the year 1760; his pupil Irvine introduced the term "capacity for heat," while Gadolin replaced it in 1784 by the term "specific heat." In connection with the determination of the specific heats of various substances, the following names are most prominent: Wilke, Lavoisier, Laplace, Kirwan, Dalton, Dulong, Petit, De la Rive, Regnault, Favre, Silbermann, Bérard, De la Prevostaye, and Desains.

As regards the air thermometer, I am inclined to think that Galileo invented it about the year 1597; some attribute it to Sanctorio of Padua, others to Cornelius Drebbel of Alcmaer, while others, again, maintain that it was discovered by each of these men independently of each other. Some of the members of the Accademia de Cimento first constructed a fluid thermometer in 1655 or 1656. Edmund Halley introduced mercury in the place of alcohol. Otto von Guericke was the first to take the freezing of water as the lowest limit of the scale, while Renaldini, in 1694, proposed the boiling and the freezing points of water as the opposite limits of the thermometric scale. A kind of rude differential air thermometer is mentioned by Sturmius in his "Collegium Experimentale sive Curiosum" (1676). Sir John Leslie described the differential air thermometer which bears his name, in 1804, in his "Experimental Enquiry into the Nature and Propagation of Heat."

Leslie's principal work is his "Essay on Heat," in which he described the radiative and absorptive power of various substances, and determined the laws which regulate the radiation of heat. He maintained, however, that air is as essential to radiation as it is to convection.

The subject of the conduction of heat was discussed at some length by Lambert in his "Pyrometrie," published in 1779, but the earlier mathematical treatment of the subject is due to Fourier, and is detailed in a paper entitled "Théorie Analytique de la Chaleur," communicated to the Académie des Sciences in 1807. His definition of conductivity is extremely lucid, and he has treated of the cooling of an uniformly heated sphere with great ingenuity and elaboration. Poisson and Carnot have also applied the higher mathematics to the elucidation of various questions connected with the science of heat, and in our day Helmholtz, Clausius, and Thomson.

Mariotte and Hooke observed that glass cuts off many of the rays of radiant heat. M. De la Roche discovered, in 1812, that radiant heat, which has passed through glass, has lost the rays which glass most readily intercepts, and that, as the temperature of the radiating source rises, so does the readiness of the radiant heat to pass through glass increase. Nobili and Melloni worked together on the subject of radiant heat. The former invented the thermopile, while the latter made the important discovery that rock-salt is very transparent to all kinds of heat, and that, by using lenses and prisms of rock-salt, dark heat rays may be refracted exactly in the same manner that light is refracted by glass. These results were published in the celebrated treatise entitled "La Thermochrose, ou la Coloration Calorrifique," and were at first received with some credulity by the Parisian *savans*.

The most notable experiments in connection with the polarization of heat were made by Bérard in 1812 ("Mémoires d'Arceuil," vol. iii.), and later by Forbes.

The Abbé Rochon endeavored to determine the comparative heating effects of the various colored rays of the spectrum as early as the year 1776; he employed a flint-glass prism and an air thermometer, and reckoned the heating power of the red rays to be about eight times greater than that of the violet. In 1798 Leslie (?), by using a differential arr thermometer, found the calorific eneigies of blue,

* Cavalieri was born in Milan in 1598; he died in 1647. The above is extracted from a work entitled "Lo specchio Ustorio: overo trattato delle settioni Coniche et alcuni loro mirabili effetti intorno al lumo, caldo, freddo, suono, et moto ancora." Bologna, 1632.

green, yellow, and red to be as 1 : 4 : 9 : and 16. In 1800, Sir William Herschell employed a small mercurial thermometer for the same purpose, and arrived at the conclusion that the hottest part of the spectrum is beyond the red rays. A detailed account of recent research on this subject (especially of the "long spectrum of the electric light") will be found in Tyndall's work "On Heat treated as a Mode of Motion."

The history of heat theories has not been alluded to above because the history of the kinetic theory was discussed at some length in the first of the foregoing lectures,* and I have elsewhere † treated of one of the phases of the material theory. Bergman's "De Materia Caloris" may also be consulted by those who are interested in this part of the subject. Of recent works on Heat I would especially mention Clausius "On the Mechanical Theory of Heat;" the treatise of Tait "On Thermodynamics; the "Théorie De la Chaleur" of M. Desains, and the "Thermodynamique" of M. Bertin.‡

It is hoped that the above facts—desultory though they be—may be of interest to those who desire to follow the literature of the science of Heat in greater detail than is possible in lectures, which are rather for purposes of demonstration than for the discussion of facts connected with the history of a science.

* "Chemical News," vol. xx. p. 13. ("Am. Repr." Sept. 1869, p. 129).

† "On the Theory of Phlogiston," "Philosophical Magazine" for January, 1868.

‡ The last two treatises are published in the "Recueil de Rapports sur l'état des Lettres et les Progrès de Sciences en France," a series of which it would be difficult to speak too highly.

EXPERIMENTS ON IRON AND STEEL.

Translated from "Génie Civil."

M. Knut Styffe, a Swedish engineer, has published the results of experiments made by him to determine the elasticity and resistance of iron and steel.

These experiments were made to elucidate the questions to which the "Diete Nationale" had called the attention of Government, with reference to the fitness of the metals of Sweden for the manufacture of fixed and rolling material, and to their value as affected by their quality.

The experiments were generally made by traction, upon bars 1.50 metres long by 125 millim. sq.; some being rough from from the forge, others finished by the file. The traction was effected by the hydraulic press, and was measured by the aid of a lever with unequal arms. In order to allow for the influence of foreign substances, as carbon, silicium, etc., which are always found in iron, a great number of chips from the bars were analyzed.

The experiments were made upon iron and puddled steel No. 2, from different forges; upon Bessemer steel and iron of different manufactories in Sweden; on the cast-steel of Dalécarlie, on Krupp's steel, on the English Lowmoor puddled iron, and others.

It was found that at ordinary temperatures permanent elongations depend on the chemical composition, on the mode of fabrication, and the manner in which the loads are applied.

Cold hammering and cold rolling increase the limit of elasticity and resistance to rupture, but diminish elongation. The action of heat produces opposite effects.

Increase of carbon augments solidity and diminishes ductility. Phosphorus in small quantity seems to have the same effect.

Tempering raises the limit of elasticity even in iron. Tempering followed by proper annealing increases resistance to rupture; without annealing, it sensibly lessens the solidity of steel.

The co-efficient of elasticity depends less upon the composition of the metal than upon the manner in which it has been worked.

Traction and hammering diminish elasticity; heat increases it; it seems also to depend on density.

The author thinks steel, particularly Bessemer steel, superior to iron in the majority of cases.

Experiments in traction with the Carré machine, at the temperature 15 deg., 30 deg., 100 and 200 C., seem to prove that. A temperature of 100 to 200 deg. C., does not sensibly affect the resistance of steel, but augments that of soft iron.

The ductility of iron and steel is not diminished by cold; that of steel, and still more that of iron, is diminished by heat.

The limit of elasticity increases with cold and diminishes with heat. The co-efficient of elasticity varies slowly at high or low temperatures.

These results seem to be contradicted by the breaking of rails and of axles, which occur in winter more frequenty than in summer; but, according to the author, this is due to the rigidity of the supports.

M. Sandberg, wishing to verify the conclusions of M. Styffe, has made experiments to determine the resistance of these metals to shocks, and has met with contrary results. He thinks this shows a difference between the laws of resistance to traction and to shock.

THE UNIFORM MOTION OF WATER IN CANALS AND RIVERS.

Translated from "Polytechnisches Centralblatt."

On the 31st of October, 1868, at Bern, Ganguillet, civil engineer, presented a paper containing a contribution to the determination of a formula for the uniform motion of water in canals and rivers. The author, in a review of the history of this question, mentions Guglielmi, Pitot, Daniel Bernouilli, Brahms and Dubuat; he then gives the formula due to Prony. $RH = aV + bV^2$, in which R is the hydraulic depth (mean radius), *i. e.*, the sectional area of the water divided by the wet perimeter; H, the fall or inclination of the surface of the water, and v the mean velocity of the water; $a = 0.000044^m$; $b = 0.000309^m$. These co-efficients were determined by Prony from 30 measurements by Dubuat and one by De Chezy. Eytelwein obtained from these 31 French measurements, and 55 made in Germany, by Brunnings, Woltmann and Funk, $a = 0.000024$ and $b = 0.000366$. Brahms, of Germany (1753), and Chezy, of France, (1755), found for velocities greater than one meter, $RH = bV^2$; in which $b = 0.0004$.

The results of experiments on many large canals, streams and conduits, gave rise to a well-founded want of confidence in the adequacy of these formulas. Darcy, *Inspecteur General des Ponts et Chaussées*, who built the aqueduct at Dijon, found, by experiments on pipes, that the condition of the interior wall affects the discharge of water; for example, that the co-efficient of resistance in old pipes is about as large as in new. Darcy and Bazin, by a series of experiments made in conjunction, proved that there is a similar effect of the condition of the wall upon the flow of water in canals. In these experiments the velocities were directly determined by the improved Pitot's tube, and at the same time the quantity of water admitted into the canal by a sluice was accurately determined. Bazin found that in the formula

$$V = C\sqrt{RH}$$

the co-efficient is not constant, but a function of R, and that in general it increases with H, but that the influence of H, and that of the profile of the canal, could be neglected; so that he deduced the formula

$$RH = \left(a + \frac{b}{R}\right)v_2$$

and determined the following values of *a* and *b* in meters:

(1.) Canals carefully lined with planed boards, or with pure cement, $a = 0.00015$, $b = 0.0000045$.

(2.) Canals with lining of rough boards, hewn stone or brick, $a = 0.00019$, $b = 0.0000133$.

(3.) Canals with lining of rubble, $a = 0.00024$, $b = 0.00006$.

(4.) Canals in earth, $a = 0.00028$, $b = 0.00035$.

Kutter, in Bern, made measurements in a stream in Switzerland, and found $a = 0.0004$, $b = 0.0007$.

At the time of Bazin's experiments, Capt. A. A. Humphreys and Lieut. H. Abbot, a Commission of the United States Government, made hydraulic surveys on the Mississippi, from the mouth of the Ohio to New Orleans. The Mississippi between these limits has an area of overflow which is nearly equal to the area of Germany. The channel has a mean breadth of 1,000 to 1,500 meters, and a maximum depth of 45 meters. Below the mouth of the Ohio the difference between high and low water is 15 meters, and the

greatest discharge is estimated at about 33,000 cubic meters in a second, with a mean velocity of 2.10 meters. The Commission, working from 1850 to 1860, considered no velocity-formula sufficient for their purpose, and that a direct determination of the law of flow of the river was necessary. Pitot's pipes and Woltmann's Tachometer could not be used in finding the mean velocity. Double floats were therefore employed, the heavier moving in the lower current, the lighter in the surface ; both connected by a small cord. The path of the float was determined by means of two theodolites at the ends of a base-line on shore. By this means it was found that the plane of maximum velocity coincided with the free surface when a strong wind was blowing down stream ; but, in case of a gentle wind blowing down, it was 0.30 of the total depth below the surface ; while in case of a wind blowing up stream it fell below the middle.

Humphreys and Abbot deduced from their measurements that the diminution of velocity, both vertically and horizontally, was indicated by a parabola, the axis of which passes through the point of greatest velocity, having for abscissas the velocities and depths for ordinates. Bazin and others find the same law. The American observers refer the retarded velocity at the surface in still air to the friction of the air ; but Bazin has proven by experiment, that in small canals such friction is not perceptible, though the greatest velocity is not always at the surface.

In the formula of Humphreys and Abbot

$$V=\left[\sqrt{0.0025\,m+\sqrt{68.7\,R_1\sqrt{H}}}-0.05\sqrt{m}\right]^2$$

$$m=0.933\div\sqrt{R+0.457}$$

V and R having same meaning as before, R_1 denotesthe sectional area divided by its perimeter. As both functions of *m* have a small value, Grebenau, a Bavarian engineer, rejects them and puts

$$V=K_1\sqrt{R_1\sqrt{H}} \quad \text{or} \quad V=K\sqrt{R\sqrt{H}}$$

since R_1 is nearly the half of R, and, therefore, $K=K_1\div\sqrt{2}$.

The limits of the change of value in K, resulting from the neglected functions of *m*, are very near each other. Kutter's comparison of this simple formula with the original, both for falls with great depth and small incline, and the converse, shows that K lies between 5.7 and 5.0 meters.

The American formula is suited to the results of the measurements on the Missisippi, and agrees with the results which Grebenau obtained from his experiments on the Rhine and the rivers of Bavaria, and does not differ greatly from the general results of measurements on waters of small incline, and depth of more than 2 meters. Kutter and Ganguillet made measurements in the summer of 1867, on canals with great slope, at Merlingen, at a time when the flow was a little greater than usual (131 cub. ft. a second). They found the mean velocity V determined by observation, and V_1 as calculated by the American formula, as follows :

(1.) At the Grünbach sluice :
$H=0.083$ to 0.107; $R=0.108$ to 0.198.
$V=3.6$ to 5.8m.; $V_1=0.8$ to 1.3m.

(2.) At the Gerbebach sluice:
$H=0.112$ to 0.237; $R=0.059$.
$V=2.6$ to 3.1m.; $V_1=0.7$ to 0.8m.

(3.) At the Gontenbach sluice:
$H=0.042$ to 0.046; $R=0.098$ to 0.112.
$V=2.9$ to 3.3m.; $V_1=0.7$ to 0.8m.

(4.) At the Alpbach sluice:
$H=0.023$ to 0.032; $R=0.209$ to 0.229.
$V=2.4$ to 2.6m.; $V_1=0.9$ to 1.0m.

In case of great fall the American formula, therefore, gives too small velocities. The same is true of Bazin's formula. This answered very well for small streams with falls greater than 1 to 100, and gives useful results for European rivers less than 6^m deep.

The experiments at Merlingen fully prove the influence of the roughness of the wetted surface. At the Gontenbach sluice, where the masonry is carefully laid with large, fair-worked stones, the actual velocities roughly agreed in the average with the velocities calculated by Bazin's formula for cut-stóne and quarry-stone ; while at the Alpbach sluice, where the work is of rough stone and damaged, the formula for rough stone gives too large results, and a roughness between that of rubble and earth must be assumed.

Applying Bazin's formula to the Missisippi, where the fall is as low as 0.0000034, the results are too small. This formula gives the greatest velocity if $R=\infty$, because in that case

$$a+\frac{b}{R}=a;$$

hence, we always have

$$V < \sqrt{\frac{R\,H}{a}},$$

Taking the value given for the smoothest walls, $a = 0.00015$, we have

$$V < 81.5\sqrt{R\,H.}$$

To a fall $H = 0.0000038$ and a hydraulic depth $R = 22.7^m$, corresponds (*e. g.* in the Mississippi) the actual mean velocity 1.21^m; hence

$$\sqrt{R\,H} = 0.009282, \text{ and } V = 130\sqrt{R\,H.}$$

The formula of Bazin therefore gives too small velocities, while the American is exact, since it gives

$$V = 5.7\sqrt{R\,H} \div (0.0000038)^{\frac{1}{4}} = 130\sqrt{R\,H.}$$

The discrepancies between the formula of Bazin and that of Humphreys & Abbot are accounted for by the fact that they correspond to extreme ratios, as in each a function of R or of H was neglected, as the influence of either was found of little importance. The author of the paper, therefore, concludes that the velocity does not always vary, either as the square root of R, as in the American formula, or as the square root of H, as in the French formula. Assuming

$$V = a\,H^x\,R^y,$$

then, if the cases represented in the above formulas be regarded as extreme, x must vary between $\frac{1}{4}$ and $\frac{1}{2}$ and y between $\frac{1}{2}$ and 1, whether H and R be great or small. A single formula with constant co-efficients of H and R cannot correspond in all cases to the results of measurements. Attemps to construct such formulas have been made by Gaukler, in France, and lately by Hagen, in Berlin. A general formula, from the results of Bazin and Mississippi experiments, has been constructed by Kutter & Gauguillet, which will be published at a future time.

THE INTENSITY OF ELECTRIC BATTERIES.

Translated from "Annales de Genie Civil."

At a late session of the Academy of Sciences of Paris, M. Th. de Moncel presented a very interesting paper on the coupling of a series of piles. The learned electrician had already, in two previous memoirs, demonstrated that the intensity of the resultant current of a series of piles is given by the formula:

$$I = \frac{n\,E}{a\,R + b\,r}$$

in which a denotes the number of groups in the series, and b the number of elements in each group. From this, it can be shown (the maximum value of I being reached when $a\,R = b\,r$) that the number of groups which must be joined in tension that a given pile may furnish for a given circuit, r, its maximum effect, is indicated by the formula:

$$a = \sqrt{\frac{n\,r}{R}},$$

while the number of elements of each group united in quantity is given by the formula:

$$b = \sqrt{\frac{n\,R}{r}}.$$

It was also observed that each of these couplings, being algebraically compared with the couplings made all in tension, or all in quantity, furnish two limits at which the electric intensities become equal, and that these limits were reached by 3, 4, 5, &c., elements united in quantity:

(1.) *In the pile disposed in tension*, when the resistance of the circuit r is equal to $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c., of the total resistance of the pile.

(2.) *In the pile disposed for quantity*, when the resistance of the circuit is $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c., of the resistance of a single element.

Again, it was seen that between these limits there was a gain in disposing the pile in series of 2, 3, 4, 5, &c., elements united in quantity, when the values of r, being less than

$$\frac{n\,R}{2},\quad \frac{n\,R}{3},\quad \frac{n\,R}{4},\quad \frac{n\,R}{5},\ \ldots\ldots$$

are greater than

$$\frac{R}{2},\quad \frac{R}{3},\quad \frac{R}{4},\quad \frac{R}{5},\ \ldots\ldots$$

These results being only the consequence of the comparison of combinations in series disposed for tension and quantity, there would be nothing to show

whether, in the comparison of the various arrangements in series, one would not find for the limiting values of r (in the conditions of maximum) dispositions more favorable to each of the syst ms of groups. M. de Moncel has undertaken to determine this.

He begins with the formulas:

$$a = \sqrt{\frac{n\,r}{R}}, \qquad b = \sqrt{\frac{n\,R}{r}}$$

and he finds values of r corresponding to the different systems of couplings at their maximum conditions. He finds:

(1.) That if $a = n$, $r = n\,R$

" $a = \frac{n}{2}$, $r = \frac{n\,R}{4}$

" $a = \frac{n}{3}$, $r = \frac{n\,R}{9}$

" $a = \frac{n}{4}$, $r = \frac{n\,R}{16}$

....

(2.) " $b = n$, $r = \frac{R}{n}$

" $b = \frac{n}{2}$, $r = \frac{4\,R}{n}$

" $b = \frac{n}{3}$, $r = \frac{9\,R}{n}$

" $b = \frac{n}{4}$, $r = \frac{16\,R}{n}$

The conclusion is, that the resistances of the exterior circuit, the most favorable to the grouping of the pile in double, triple, quadruple, etc., elements, correspond to the number expressing the total resistance of all the elements of which the pile is composed, divided by the square of the number of elements which constitute each of the groups of these different combinations.

Upon this principle, using the number 931, which represents the resistance of a Daniell element, expressed in metric units of a telegraphic wire of 4 millimetres, we find that for a Daniell of 12 elements the best conditions of use are:

(1.) In 12 series of simple elements, when r = 11172m.

(2.) In 6 series of double elements, when r = 2793m.

(3.) In 3 series of triple elements, when r = 1241m.

(4.) In 4 series of quadruple elements, when r = 698m.

(5.) In 2 series of sextuple elements, when r = 310m.

(6.) In 1 series of 12 elements in quantity, when r = 77m.

Considering the question under another point of view, it is also seen that when r is equal to

$$n\,R,\ \frac{n\,R}{2},\ \frac{n\,R}{3}\ldots.,\ R,\ \frac{R}{2},\ \frac{R}{3},\ \ldots.$$

a does not correspond to

$$n,\ \frac{n}{2},\ \frac{n}{3}\ldots\ldots,$$

as the limits in question seem to indicate, but to

$$n,\ \frac{n}{\sqrt{2}},\ \frac{n}{\sqrt{3}},\ \ldots.\ \sqrt{n},\ \sqrt{\frac{n}{2}},\ \sqrt{\frac{n}{3}}\ldots.$$

while

$$b = 1,\ \sqrt{2},\ \sqrt{3}\ldots.$$

In the first memoirs M. de Moncel has shown the values of a and b, corresponding to a given intensity I. These formulas are:

$$a = \frac{2\,I\,r}{E}, \quad b = \frac{2\,I\,R}{E},$$

But, that these may be applicable, r must be less than $n\,R$. For it is only when b is greater than unity that the maximum is reached when $a\,R = b\,r$.

IRON AND STEEL NOTES.

Furnaces for Melting Steel.—Mr. J. Suter, of Hereford, and Mr. T. Hinde, of Fownhope, near Hereford, have patented an invention which consists in constructing furnaces for melting steel and for other purposes, and in the combustion of fuel in the furnaces, by which means great economy of fuel is said to be effected, a higher temperature obtained, and great control over the action of the furnaces at the same time secured. These improvements are also applicable to the furnaces of steam boilers. The furnace is constructed of three principal parts, namely, of a gas-generating chamber, a combustion chamber, and a superheating chamber. In the first or gas chamber, the solid fuel is converted into gaseous fuel by being ignited and supplied with a sufficient quantity of air to convert the carbon of the fuel into carbonic oxide. The second chamber of the furnace consists of a reverberatory chamber, into which gaseous fuel produced in the first chamber, mixed with the requisite quantity of air for combustion, is burned. In the third or supplementary chamber, the gaseous fuel is heated prior to being burned in the combustion chamber. The gas-generating chamber is of iron, lined with fire-brick, and having an opening at the bottom through which the clinker can readily be removed, or the clinker may be fluxed out by charging a little lime with the fuel.

Fuel is supplied to the gas-generating chamber by an opening at top closed by a valve, which permits of the introduction of the fuel without material loss of gas. The requisite quantity of air is introduced into the gas-generating chamber from a fan, and is delivered into the chamber by a tuyere. In order the more effectually to bring the air into contact with the ignited fuel where the fuel is very

small or in a fine state of division, it is delivered into the chamber by a series of small openings in the tuyeres instead of by one or two large openings. The combustion chamber, in which the gaseous fuel is burnt, and in which the steel is melted or the other operations of the furnace performed, has a size and form suitable to the particular use to which the furnace is applied. The gaseous fuel is heated before it is introduced into the combustion chamber, so as to raise its temperature and thereby produce a more intense heat in the furnace, either by passing it through heated tubes or by allowing it to undergo combustion. When the gaseous fuel is heated by the former method, a heating chamber is constructed above or in connection with the combustion chamber, through which heating chamber the waste heat from the combustion chamber is passed. Fire-clay tubes, passing through the heating chamber, conduct the gaseous fuel to the combustion chamber, which gaseous fuel is superheated in its passage through the tubes. When the heating of the gaseous fuel is effected by its own combustion, atmospheric air is mixed with it and it is ignited. The gaseous fuel which has thus been burned, is passed through ignited carbonaceous matter, whereby it takes up carbon, and becoming revivified or reconverted into combustible gas, passes to the combustion chamber strongly heated and with its full combustible power. By heating gaseous fuel in the ways described, an intense heat is produced in the combustion chamber. When the furnace is used for reducing metallic ores, the gaseous fuel is not superheated by the waste heat from the combustion chamber, but the gaseous fuel passes into and through the combustion chamber to the superheating chamber and is burnt in the superheating chamber.

In applying these improvements to the furnaces of steam-engine boilers, the superheating of the gaseous fuel is unnecessary. By varying the quantity of air mixed with the gaseous fuel during combustion, the character of the flame produced may be varied so as to possess either a reducing or an oxidizing action. As a convenient means of ascertaining the character of the flame, the inventors employ in the furnace a small lump of coal and a lump of peroxide of manganese. When the flame has an oxidizing character, the gaseous fuel volatilized from the coal burns with a bright light, while there is no apparent action on the manganese. When the flame has a reducing character, there is no flame from the coal, but the lump of oxide of manganese becomes intensely ignited by the combustion which takes place on its surface between the oxygen evolved from it and the carbonaceous matter of the gaseous fuel.—*The Mechanics' Magazine.*

NOTES ON THE FRENCH IRON TRADE.—The Paris, Lyons, and Mediterranean Railway Company has just let a contract to Messrs. Schneider, of Creusot, for 5,000 tons of steel rails, at a price of £12 12s. a ton at the works, subject to the condition that a deduction will be made from the price after the expiration of Mr. Bessemer's patent right; this deduction is estimated at £1 3s. 4d. a ton.

The Northern Railway of France has decided upon replacing with steel, the whole of the iron rails upon the line, at an estimated cost of £52,000.

Partial contracts have recently been let for the iron work of a large covered market in Naples, designed upon the plan of similar buildings in Paris. The wrought-iron work, to the amount of about 1,500 tons, is divided amongst two or three different works. The contract for the cast-iron columns, amounting to some 2,500 tons, are not yet given out.

The bridge and viaducts, 53 in all, on the Latour and Milhan section of the line between Rodez and Montpelier, are in course of construction by Messrs. G. Eiffet and Co., of Lavallois, Paris.

The new "Société des Forges et Chantiers de la Mediterranée" has in course of construction an iron floating dock for the Viceroy of Egypt. The following are its principal dimensions:

	ft.	in.
Total length	463	5
Width inside	78	$8\frac{7}{8}$
Width of side chambers	9	10
Total width	88	6
Depth of the bottom framing	8	$2\frac{3}{8}$
Height from bottom framing to top of dock	28	$10\frac{5}{8}$
Total height	36	1

The bottom skin of the dock is made of two thicknesses of $\frac{7}{16}$ in. plate; the sides of $\frac{5}{8}$ in. plates at the bottom, decreasing gradually to $\frac{3}{8}$ in. at the top. The plates of the framing are $\frac{1}{2}$ in. thick. The strakes are $24\frac{1}{2}$ in. wide, and at intervals of 16 ft. 4 in. they are strengthened by vertical angle-iron, strengthened with gusset plates. The plates forming the bulkheads are $\frac{5}{8}$ in. thick. The total weight will be about 4,500 tons.

The iron bridge to cross the Seine at Vernon, and to carry the Gisors and Vernon Railway, is in course of construction. The total length of the bridge is 705 ft., and it is being constructed complete on the bank, upon a platform, from which it will be launched across the river. The weight of the structure will be about 400 tons.

The suspension bridge across the navigable arm of the Seine at Melun, carrying the Imperial road, which connects Brie with Froissard, is about to be removed, and an ornamental cast-iron arched bridge in two openings will be erected in its place. The estimated cost is £9,200.—*Engineering.*

IRON AND STEEL CRYSTALS.—M. Schott, of Ilsenberg, has made many microscopical examinations of the structure of steel and iron. He maintains that "all crystals of iron are of the form of a double pyramid, the axis of which is variable, as compared with the size of the base. The crystals of the coarser kinds, as compared with those of the finest qualities of crystalline iron, are of about twice the height. The more uniform the grain, the smaller the crystals, and the flatter the pyramids, which form each single element, the better is the quality, the greater is the cohesive force, and the finer the surface of the iron. These pyramids become flatter as the proportion of carbon contained in the steel decreases. Consequently in cast-iron and in the crudest kinds of hard steel, the crystals approach more the cubical form, from which the octahedron proper is derived, and the opposite extreme or wrought-iron has its pyramids flattened down to parallel surfaces or leaves, which in their arrangement produces what is called the fibre of the iron. The highest quality of steel has all its crystals in parallel positions, each crystal filling the interstices formed by the angular sides of its neighbors. The crystals stand with their axes in the direction of the pressure or percussive force exerted upon them in working, and consequently the fracture shows the sides or sharp corners of the

parallel crystals. In reality, good steel shows, when examined under the microscope, large groups of fine crystals like the points of needles—all arranged in the same direction and parallel.—*Journal of Applied Chemistry.*

ARTIFICIAL PORPHYRY FROM IRON SLAGS.—At the iron-works of Aulnoye, in Belgium, the slag is utilized by casting it into slabs for pavements, garden rollers, and other things. For the former purpose, moulds are excavated in the ground around the furnaces of sufficient extent to receive all the slag running from them, and trenches are cut to carry the liquid slag. The only precaution to be taken, we are told, is to cause the slag to run under the vitreous layer, which solidifies at the beginning of the running, and to keep the moulds warm, so that the slabs may not solidify too rapidly. For this purpose it is often necessary to cover up the trenches and moulds with cinders and small coal. The cooling should, indeed, be made to occupy several days; and, in that case, there will be found under the vitreous crust a compact homogeneous slab, in appearance very much resembling natural porphyry. The masses are often divided by fissures, but the pieces can be dressed and trimmed into blocks for paving. To obtain sound rollers, it is necessary to take especial care in the cooling and solidifying. It is hardly necessary to add that the slags employed for these purposes must be solid and lasting, and not at all brittle.

OBTAINING MALLEABLE IRON OR STEEL FROM CAST-IRON.—The invention of Mr. J. B. Spence, of Manchester, relates to that method of obtaining malleable iron or steel from cast-iron which is now known as the Heaton process, or to other processes in which nitrate of soda, or other similar chemical salts, are used for oxidizing substances combined with the iron, and consists in a method of using the said salt, whereby its decomposition is to a certain extent retarded. For this purpose he brings the nitrate of soda, or other salt, into a more or less solid body before the melted iron is allowed access to it. This solidification may be effected by pressure, by fusion, or by other means. The process of solidification may be effected in the chamber which is used for receiving the converted iron, or in separate moulds, and Mr. Spence proposes to bind the edges of the consolidated cake of the salt to prevent its rising, or the passage of the metal beneath it by bevelled edges, projections, or other such means. In order when desired to weaken the power of the chemical agents, he adds thereto any suitable diluents.—*Mining Journal.*

CANADA RAILS.—The chairman of the Grand Trunk line, says, with regard to the Toronto rolling mills, it has been found that rails rolled there would last as long as three or four times the number of rails shipped from England to Canada during the last 3 or 4 years. The Toronto re-rolled rails are acknowledged to be the best rails that can be made in Canada, and a few weeks before he left Canada, as a great favor, they allowed the Great Western of Canada Company to have 300 tons of rails re-rolled at the company's Toronto rolling mills.

RAILS IN FRANCE.—A table prepared in illustration of the production of rails in France during the last ten years presents the annexed results: 1859, 101,426 tons; 1860, 121,438 tons; 1861, 164,371 tons; 1862, 216,175 tons; 1863, 226,948 tons; 1864, 215,983 tons; 1865, 184,131 tons; 1866, 159,061 tons; 1867, 154,351 tons; and 1868, 202,204 tons. The average price per ton in 1859 was £10 2s. per ton, while in 1868 it had fallen to £7 2s. per ton.

BESSEMER RAILS IN FRANCE.—The consumption in the first six months of this year amounted to 19,755 tons, against 10,562 tons in the corresponding period of 1868; it is probable that the French production of this description of rails will show a still further advance in the second half of 1869, as large orders have been given out during the last two or three months by the great French railway companies.—*Engineer.*

IRON IN GREAT BRITAIN.—The furnaces in blast in 1868 were 560; pig-iron in Great Britain amounted to 4,970,206 tons, an increase of 209,183 tons over 1867. In England the make was 2,970,905 tons, an increase of 159,959 tons; in Wales and Monmouthshire, 931,301 tons, an increase of 12,221 tons; in Scotland, 1,068,000 tons, an increase of 37,000 tons.

RAILWAY NOTES.

THE FESTINIOG RAILWAY.—The little Festiniog Railway of 2 ft. gauge, presents a striking example of commercial success, and did its yearly accounts come before the general public they might, perhaps, create a feeling of astonishment. The original capital of the company was £36,000, applied to a line of 13 miles, but, their borrowing powers being exhausted, they have since almost reconstructed their line, erected workshops, manufactured their rolling stock, etc., wholly out of revenue, until the whole expenditure now stands at about £86,000, the company having this year obtained powers to capitalize the revenue thus applied.

In the year ending June 30th, 1868, the train mileage was 46,732 miles, averaging six trains each way daily for the 313 working days of the year, or, say, 1878 down trains loaded with slates. The weight of slates taken into Portmadoc was 112,053 tons, equal to nearly 60 tons per train, while 14,693 tons of merchandise were carried on the return trips, besides passengers, both ways, paying £3,381. The slate trucks, of course, return empty from Portmadoc to the quarries, the earnings from slate traffic being wholly derived from the down trains, although, by the usual railway fiction, the trains which really run all the way down hill, are, we believe, called "up trains." The carriage of slates returned £15,798 18s. 7d., equal to nearly 2s. 10d. per ton carried for the 13 miles down, or 2d. per ton per mile, and 13s. 6½d. per down train per mile. The total receipts were £22,852 13s. 5d., or 9s. 9¾d. per train per mile in both directions. The working expenses were £9,700, or, say, 42 per cent. of the earnings; but of this sum, £1,223 were royalties paid under the name of "tonnages," £779 were parish rates, £382 passenger duty and income tax, £1,481 for station masters and staff, etc., the charge to locomotive department being £700 only. The actual locomotive expenses are very moderate, notwithstanding that with driving wheels but 2 ft. in diameter, and with coal at 15s. per ton, the cost of fuel is necessarily rather high. Thus it will be seen that the net profits of this little railway have

amounted to more than 40 per cent. of the original capital, and to upwards of 12½ per cent. on the total outlay on the undertaking, the larger portion of which has been paid out of revenue.—*Engineering.*

CHINESE TIME TABLE—VALUE OF KNOWING HOW TO READ.—The Chicago "Railway Review" notices a request from Samuel Lewis, who, we believe, is connected with the Western Pacific Railroad, either as an engineer or conductor—for copies of that paper for himself and friends. The "Review" appends this paragraph:

"Mr. Lewis incloses in his letter a quaint comglomeration of hieroglyphics on a half sheet—a Chinese time-table—which he says is used by Chinese conductors on the line, and which it is necessary for all conductors to learn. So, a candidate for a conductorship on these lines, we naturally infer, must acquire a more than ordinary degree of linguistic facility before he is competent to run a train west of Promontory."

Chinese time-tables may be very useful. But before this linguistic accomplishment is attained it might be well for railroad servants to know how to read English. We cannot vouch, for instance, that the switch-tender at Simpson's Station did not know how to read a Chinese time-table; but he could not read it in English, and this disability caused the loss of a dozen lives. A Chinese switch-tender, reading the time-table in his own tongue, would probably have arrested this dreadful calamity. But as the railroad servants are not Chinese, it might be well enough to begin with the acquisition of English first, and afterwards, if there is any gain, finish off in Chinese. Considering the number of accidents which have occurred since the first calamity, after reading Mr. Lewis's facetious description of what is required of a conductor, one might infer that Chinese time-tables are still used to the exclusion of any other.—*San Francisco Bulletin.*

A WONDERFUL TEAM.—On Saturday last there was seen on the streets of Leith a wonderful train of mechanism. It consisted of a ten-horse power road steamer, with two companions of equal size in tow to the docks for shipment. To those who have been in the habit of seeing heavy machinery dragged along by some sixteen or eighteen horses, and who have witnessed the kicking, plunging, swearing, and uproar which invariably accompany such undertakings, it must have been pleasant to observe the quiet smile on the driver's face as he silently picked his way along the street. Although the roads were in the worst possible condition, being thick with greasy mud, the journey to the ship's crane was effected so smoothly and easily that it did not offer a single incident for description. All that can be said of it is, that it was the simplest performance in the world. The road steamer, which was acting as tug to its two mates, was exhibiting its maiden effort, as it had only just been completed, and had never been out before. It is a ten-horse power engine, nominal, but can develop up to thirty-horse power. Its weight on the road is from eight to nine tons. The diameter of the wheels is 6 ft., the breadth of the india-rubber tyres is 15 in., their thickness is 4½ in. Messrs. T. M. Tennant and Co. (Limited), Bowershall, Leith, have obtained a license to manufacture Mr. R. W. Thomson's patent road steamers and steam omnibuses with india-rubber tyres, and they are making arrangements on a large scale to keep pace with the numerous orders received, and to turn out the engines with great dispatch.—*Engineering.*

PROGRESS OF FRENCH RAILWAYS. The Table which we subjoin shows the state of progress of the principal French lines at the end of last year.

NAME OF RAILWAY.	Number of Miles Open.	Number of Miles in Course of Construction.	Number of Miles for which Concessions have been Obtained, but which have not yet been Commenced	Total.
Paris. Lyon et Méditerranée	1510	569	782	8861
Orleans	2307	198	202	2707
Est	1667	194	102	1963
Ouest	1375	126	297	1798
Midi	1067	188	340	1595
Nord	891	60	52	1003
Charentes	73	22	290	385
Other companies	200	98	132	430
Totals	10,090	1455	2197	13,742

Besides these principal railways, there are to be found distributed in seventeen departments of France a number of cheaply constructed local lines, or "chemins d'intérêt local" as they are called, these lines having an aggregate length of 611 miles, and being in many instances of a narrower gauge than the lines forming the main network. There are also 33 "chemins industriels," connecting various mines and quarries with the main system, these lines having at the end of 1868 a total length of 103 miles, and an additional 6¼ miles being in course of construction. The longest of these lines is that extending from Commentry to the Canal du Berry near Montluçon, which is altogether about 12 miles in length.

Of the same class as the "chemins industriels" are the various branches belonging to the main lines, which serve to connect the latter with various mines, works, depôts, etc., and there are altogether 527 of these branches in France, their aggregate length being 170 miles. Of this total length 87 miles are worked by locomotives, 73 miles by horses, 11½ miles by manual labor, and 1½ miles by other systems of haulage. The greater number of the small branches we have mentioned belong to three of the principal railway companies, the Paris, Lyons, and Mediterranean having 156 branches, the Northern 129 branches, and the Eastern Railway 109 branches. The Paris and Orleans Railway, the second longest line in France, has but 39 of these small branches.

The total net receipts (after deduction of duty of 10 per cent.) on the French lines during 1868 was £27,320,000 or about 2,707 per mile, a sum which closely agrees with the receipts on the lines of the United Kingdom during the years 1867-8. In this latter year there were 14,247 miles of line open in the United Kingdom, and the total traffic receipts were £39,479,999 or £2,270 per mile, while last year the receipts per mile had increased to £2,960. The total number of passengers carried by the French railways during 1868 was 94,000,000, against 287,631,113 carried by our own lines dur-

ing 1867, and the working expenses amounted in 1868 to 47.8 per cent. of the receipts on the French lines, and 49.5 per cent. of the receipts on the lines of the United Kingdom. In conclusion, we give the following details of the traffic and receipts, etc., on the French lines during 1868, which we think are of sufficient interest to warrant our recording them:

Total weight of goods carried	47,500,000 tons	
Mean distance traversed by each ton of goods.........		80.7 miles
Mean distance traversed by each passenger...........	24.8	"
Passenger train mileage.....	2,342,400,000	"
Slow goods train............	3,852,500,000	"
Total train mileage of all kinds	6,871,120,000	"
Mean receipt per train per mile		96.6d.
" expenditure " "		45.9d.
" charge per mile per passenger....................		0.95d.
Mean charge per mile per ton		0.96d.
" net earnings per train per mile.................		50.07d.

—*Engineering.*

Railways and Climate.—It is said that the Pacific Railroad is working a great change in the climate of the Plains. Instead of continuous droughts, all along the railroad, rain now falls in refreshing abundance. In Central Ohio, for example, it is said the climate has been completely revolutionized since iron rails have formed a network all over that region. Instead of the destructive droughts formerly suffererd there, for some four or five years there has been rain in abundance —even more than enough to supply all the wants of farmers. This change is thought to be the result of an equilibrium produced in the electrical currents, which has brought about a more uniform dispensation of the rain It is a fact within the observation of all who remember anti-railroad times, that there are now few or no such thunderstorms as formerly took place in New England.

Locomotive Statistics.—The following is the report of the general average of performance of locomotives on all divisions of the Michigan Central Railway for the month of October, 1869, as made by A. S. Sweet, Locomotive Superintendent:

Number of freight cars drawn one mile..	2,127,772
Equal to cars drawn over the entire line.	7,492
No. freight cars drawn one mile in Sept.	1,973,568
Equal to cars drawn over entire line Sept.	6,949
No. miles run to one pint of oil.........	15.11
" " " " " cord of wood......	33.38
" " " " " pint of oil in Sept..	15.38
" " " " " cord of wood......	35.22
Average of freight trains...............	23.65
" " " " in September...	21.04
No. of gallons of oil used.............	1,807
" " cords of wood used............	4,857
" " tons of coal used...............	1,643
Average number of miles run per ton by coal-burning engines..............	35.99
Average number of miles run to one ton of coal in September................	39.55
No. of miles run by passenger trains....	76.783
" " " freight trains.......	96,307
" " " miscellan's trains...	13,374
" " " training engines....	32,080
Total..........................	218,544

Bridges on the Burlington and Missouri Railway.—Whatever the degree of security attained in the road bed, a line crossing five or six hundred bridges must show no inferior excellence here. The problem was, of course, that of wooden bridges to start with, there not being time to construct stone ones (even if the material were everywhere at hand), and the expensiveness of iron putting it out of the question. The bridges, so far as concerns the needs of the road for several years, are most emphatically first class. The design, original with the engineer, exactly meets the circumstances of the case, and its excellence needs no higher verification to those who cannot visit the road, than the fact that it has been adopted on the Union Pacific, the Superintendent of Construction of which road was for some time Mr. Thielsen's assistant here. They all rest on pile or stone foundations, the low bridges (from 12 to 16 ft. high) on piles; beyond that height they become "bent" bridges of one, two, and even three "stories," resting either on pile or stone foundation. The peculiar feature is the manner in which the superstructure is bound together, so as to make it as emphatically *one* structure as the best iron bridge can be. The span of the trestle are either 16 or 20 ft.; upon the caps rests a system of stringers, varying from 6 to 8 in number under the track; the dimensions of the timbers being, on the 16-ft. span, 5 x 16 in., and on the 20-ft. span, 6 x 16 in. These stringers only reach from bent to bent, abutting against each other; and the different sets are from 14 to 16 in. apart from centre to centre. In these openings, and resting upon the cap, is a splice of the same size, but only half the length of the stringers, locked down upon the cap 1¼ in., both splices and stringers being bolted together. In the intermediate spaces the bolts pass through cast-iron washers, keeping everything in position, which, when the nuts are screwed on, bury their sharp edges in the wood, binding the whole into one mass. The strength of this simple and admirable splice has undergone an *experimentum crucis*, in the case of a train passing rapidly over a span, the bent beneath which was afterward found to have been washed out. Upon the stringers are placed the ties, 16 to every 20 ft., which, in turn, are held in position by longitudinal fenders, slotted down upon them; the whole fastened to the stringers with fender bolts passing through fender, tie, and stringer, every 8 ft. In passing over the bridges the engineers feel under no necessity to materially slacken speed, and the structure is free from perceptible vibration beneath the heaviest or swiftest train. Over the larger rivers the length of the bridges is about 1,200 ft., that over the Des Moines being half a mile. After leaving the bridge, the embankments are broken up at regular intervals with trestle work, to give the freshet overflow a free communication to all parts of the bottom. The bridges, except those built the past season, are nearly all inclosed above. The bridge connecting the C. B. & Q. and B. & M. R. R., was finished in 1868; is of iron, 2,200 ft. long; has 9 spans of 250 ft. each, the draw being 360 ft.—*Chicago Railway Review.*

Snow on the Union Pacific Railway.—In the matter of snow protection, what has been done is, in brief, this: At all exposed points, permanent sheds, 8 miles in all, will be completed by Jan. 20; by which time 150 miles of snow fence will be completed. The force engaged for six weeks on

this work has numbered 300 men. The fence, of original design, and answering the end perfectly, merits a description. The supports (8 ft. apart) consist of two posts (2 x 6 in., 8 ft. long) joined together (by means of a bolt) in the shape of an X, at about one-third of the distance from their top. On the outside of these, common fence boards are nailed—three on the upper part of the one and four on the lower part of the other. In most places, *two* of these fences are built—the outer 100 feet from that nearest the track. The protection is perfect.—*Chicago Railway Review.*

ORDNANCE AND NAVAL NOTES.

Palliser Converted Guns.—The complete success which has attended the conversion of upwards of 400 cast-iron 8 in. smooth-bores into Palliser rifled cannon for the Admiralty has lately attracted the attention of the War Office to the importance of converting the thousands of 68-pounder cast-iron guns which are mounted on our coast defences both at home and abroad. Out of several hundred guns which have now been proved, in no instance has the slightest symptom of weakness presented itself. These conversions are due to the reports and recommendations of General Lefroy and the members of the late Ordnance Committee, and the practical results reflected great credit upon their labors. The recent visit of Colonel Jervois, the Deputy-Director of Fortifications, to Halifax and Bermuda has been the means of further demonstrating the importance of the subject. It appears that at the latter place alone upwards of 300 smooth-bore guns are mounted in the works, and although complete in their carriages, traversing platforms, embrasures, sponges, rammers, etc., they are, in their present smooth-bore state, no better than wooden dummies for opposing a bombardment at long ranges with rifled guns. The Secretary of State for War has, as a preliminary measure, authorized the trial at Shoeburyness of two rifled guns, a 7 in. and an 8 in. converted from 68-pounder guns. They are to be fired at the "Warrior" target from a distance of 1,000 yards. The experiment is awaited with great interest, since if the guns penetrate the target at such a range, it is expected considerable orders for conversions will follow. An old cast-iron mortar has also been converted, by Mr. Cardwell's directions, into a 9 in. rifled mortar, and will be tried at the same time as the guns. It weighs about 6 tons, and it is expected that it will throw its shell of 250 lbs., containing a bursting charge of 20 lbs. of powder, upwards of 7,000 yards.—*Mechanics' Magazine.*

Experiments at Shoeburyness.—A further short trial of four rounds was made at Shoeburyness on Wednesday to test the clutch arrangement of the screw compressor head of Vavasseur's 7 in. steel gun-carriage, alluded to in our former notice of November 26.

The details of the rounds were as follows:

Round	Elevation.	Charges l. g. r.	shot	Compressor at	Recoil ft. in.	Time of Flight.
1..	7 deg. ..	14 lbs. ..	114¾ lbs. ..	2½ ..	0.5 ..	9.3 secs.
2..	7 deg. ..	14 lbs. ..	114¾ lbs. ..	2 ..	0.6¼ ..	9.3 secs.
3..	7 deg. ..	22 lbs. ..	114¾ lbs. ..	2 ..	1.7½ ..	9 5 secs.
4..	7 deg. ..	22 lbs. ..	114¾ lbs. ..	2 ..	1.0 ..	9.8 secs.

In the above practice the slide drove back at each discharge about 4 in., in consequence of the bad holding afforded by the marshy ground, and in this way was gradually carried off the racers on to the platform, rendering exactitude of recoil out of the question. It was clear, however, that the clutch arrangement effectually answered its purpose of securing the mechanical hold of the coned head on the friction drum during the recoil of the gun.

Including Wednesday's practice, the total fired is now 145 rounds, composed of the following items:—2 proof rounds of 27 lbs., at Woolwich Arsenal; 10 service charges of 14 lbs., and 9 battering charges of 22 lbs., at Yarmouth; 50 battering charges at Woolwich; 56 battering charges at Portsmouth; and 8 service charges and 10 battering charges at Shoeburyness. The gutta-percha impressions taken after the last previous practice show no sign of wear in the gun.—*Army and Navy Gazette.*

Achilles, 26, screw armor-plated ship, Captain Mathew S. Nolloth, coast-guard ship at Portland. On the 27th ult. this ship went outside the breakwater at Portland for the final trial of the patent hydrostatic steering apparatus invented by Rear-Admiral Inglefield, C.B., and which has been recently fitted to the Achilles. It was then, as upon former occasions, clearly shown that by its use one man in the pilot-house on the bridge can put the helm over the largest ship, when going at full speed, in a space of time and with a power that has never been approached by the efforts of forty men exerted on the ordinary steering wheel, and not surpassed by the steam steering gear which is applied to the Northumberland, employing still the ancient appliances of long tiller and ropes, etc. It may be asked, What are the advantages of the power the Admiral employs as a motor over steam? And this may be briefly answered thus: In the first place, he utilizes an enormous accumulative power which exists outside of every floating vessel, whether at rest or in motion, that power being greater in proportion to her depth of immersion. Thus, a ship like the Achilles, drawing 26 ft. of water, can utilize an external pressure of water at the bottom of the vessel equal to from 8 to 10 lbs. on the square in. To make this available for the purposes of steering the vessel, the Admiral admits water through a Kingston valve in the bottom of the ship to a cylinder lying on the keel. An internal piston, moving by the pressure due to the column of water, and made to change its direction by a self-acting reciprocating movement, conveys the power to a ram, which multiplies the pressure first obtained in proportion to the areas, and from thence through two 2-in. pipes, conveys a column of water at a mean pressure of 300 lbs. on the square in. to hydraulic presses, which act on the lower tiller at a radius of 4 ft. from the rudder-head. The power is directed to either side of this short tiller by means of a directing slide, which is moved by a long rod set in action by the small wheel in the pilot-house. At either extreme of its movement, which does not exceed 5 in., the high-pressure water is forced to either the starboard or port tiller cylinder, putting the helm over with an irresistible force in the opposite direction. At the middle part of the movement of the directing slide, a free communication is opened between the two tiller cylinders, and then the rudder will right itself when the ship is going through the water. At this position, too, the ordinary steering wheel

may be used, as though the new apparatus did not exist. On the lower deck there is a corresponding small wheel to the one in the pilot-house, to be used when the ship is in action. These wheels are used in precisely the same manner as the ordinary wheel, the only difference being that from hard a-starboard to hard a-port it has only to be made to revolve $\frac{5}{8}$ths of its whole circumference. The advantages claimed by the inventor over all steam steering apparatus are these: 1. The water engine placed on the keel of the ship, in a spot unoccupied by anything else, requires no personal superintendence; it is always ready at a moment's notice, and costs nothing to keep. 2. Water, being incondensible and incompressible, is more suited for the working of an apparatus which may lie almost completely idle for hours, but must, nevertheless, be ready for use at the shortest notice, and to its fullest extent. 3. As a fighting gear for the helm, it possesses the property of requiring the smallest tiller possible, with an attachment placed more completely out of gunshot than any yet invented. The official report of the trial of the Achilles, on June 23, set forth the following advantages and shortcomings: 1. Sufficient motive power always available. 2. The steadiness with which the power applied overcomes the resistance of the rudder at the highest rate of speed, especially when the helm is nearly hard over. 3. The security with which the rudder is held at any desired point. 4. The readiness with which the rudder is freed after being hard over, and thereby allowed to right itself rapidly when going at speed. 5. The ease with which the power is applied, one man being able to use it under any circumstances. 6. The facility with which the tiller is connected with, or disconnected from, the hydraulic rams. The defects of the apparatus appear to be at present: 1. Want of rapidity in action. A certain limit of time for the process of putting the helm hard over from amidships should be made an indispensable requisite—not more than 45 seconds, and not less than 30 seconds. 2. The egress of the water from the pumping engine to the bilge is not sufficiently free. These shortcomings have been fully overcome by the improvements made since the date of that trial, for it was reported then that the helm went over every time to about 25 degs. in 10 seconds, the maximum angle obtained by the ordinary wheel being 24½ degs. in 1 minute and 17 seconds. The pumping engine has been much improved; but it is intended in the Turkish iron-clad, which is now being fitted with Admiral Inglefield's apparatus, on the recommendation of the Chief Constructor of the Navy (Mr. Reed), to put a far simpler and less expensive form of water-engine.—*Army and Navy Gazette.*

ENGINEERING STRUCTURES.

Strength of Unstayed Flat Surfaces to Resist Pressure.—At a recent meeting of the Liverpool Polytechnic Society, Mr. Lauder read a paper, of which the following is an abstract, entitled "Strength of Unstayed Flat Surfaces under Pressure."

The object of this paper is to lay before the Society some considerations that guided the writer in designing a digester under somewhat unusual conditions, for the firm of Messrs. Rose & Gibson, to be used in their new process of utilizing cotton seed.

The conditions required to be fulfilled were that the bottom should be flat, that there should be no internal stays, and that it should be sufficient to withstand a working pressure of 30 lbs. per square inch. The *factor of safety*, determined on from the nature of the work to be performed, was the same as that in common use for steam boilers, viz., 8. Thus, the bursting pressure is 240 lbs. per square inch. The method of strengthening the bottom by outside girders was selected in preference to bracing, for the sake of convenience with regard to the position it had to occupy. The distance of the girders from each other is one foot from centre to centre. The girders are proportioned so as to resist the entire pressure on the bottom of the vessel, each girder supporting a load of the amount of the pressure on a surface equal to the length by the distance between two girders. It is worth observing that the bottom of the vessel serves also for the top booms of the girders. The next point to be considered is the thickness of the bottom, to ascertain that it is strong enough between the girders to sustain the pressure without staying. The portion under consideration is evidently in the condition of a rectangular beam fixed at the ends, and is consequently simply under the laws which govern the breaking of beams. For calculation it is convenient and sufficient to consider a strip one inch broad, stretching between the girders. The advantage arising from end fastenings being neglected, we find a very simple adaptation of the ordinary formula for the strength of girders leads to a general formula for surfaces under such conditions: t = thickness of plate; c = half distance between supports; f = modulus of rupture—wrought-iron bars = 54,000; cast-iron bars = 33,000 to 43,500; W = bursting pressure on a strip unit breadth between supports; p = bursting pressure.

$$t^2 = \frac{c\,W}{\frac{1}{3} f}$$

$$\text{But } W = p \times 2\,c.$$

$$\therefore t^2 = \frac{p \times 2\,c}{\frac{1}{3} f}$$

—*The Engineer.*

The Well at Prospect Park.—The great well of Prospect Park, Brooklyn, built under the direction of C. C. Martin, the engineer, is thus described in the "New York Times:"

"The outer wall is fifty feet in diameter, two feet thick, and fifty-four feet high. The inner curb, or wall, is thirty-five feet in diameter and two feet thick, having a depth of ten feet. The masonry, as seen from the top of the structure, is a marvel of neatness and solidity. The water surface in the well is thirteen feet above high-tide level, and the depth of water in the well is fourteen feet. The pump foundations are entirely independent of the walls. This plan was adopted so as to obviate any possible difficulty which might arise from displacement. The pump is the Worthington patent, and, with a pressure of forty pounds, is capable of raising one million gallons of water every twenty-four hours a height of 176 feet, and is competent to a lift of 180 feet.

"The boiler house is a neat, pressed-brick structure trimmed with Ohio stone, standing on the surface near the mouth of the well. The interior

of the well is reached by a spiral stairway built in the wall, and commencing in the boiler house. In this way the engineer is able to reach the pump. It is a fact worthy of notice in connection with the construction of the wall, or rather the sinking of it, that the outer wall rests upon four feet of wooden cribwork, two feet thick, and having an iron shield. The inner wall is built upon a similar crib only two feet deep, also shielded with iron.

"The Commissioners were led to the construction of this well in presence of the danger at any time of some accident taking place in connection with the Brooklyn Water Works, which would render it necessary for the Water Board to cut off the Park supply so as to secure the citizens from suffering. This well has more than the necessary capacity to supply the Park abundantly with water, yielding most when most is needed. This is established by the discovery that the time of drought from which the well is, or may be, likely to suffer, occurs in the Fall. Besides these facts, it further appears that in order to furnish the supply of water to the Park the Water Board would have to go through the process of pumping their water twice to convey it to the required elevation, equal to 225 ft. from its original level.

"The work of the well will be to supply the pools at an elevation of 133 ft. From the pools the water is conducted to the lake. Besides this, there is an independent connection with the lake by which, as necessity may suggest, the water can be directed to the lake, a lift of only 70 ft. The lake, when completed, will occupy an area of fifty acres, which will be kept continually supplied with fresh water, the arrangements being such, or to be such, as will insure a permanent change of water, and prevent any of the evils that may arise from stagnancy. The well is fed from the earth, consisting of a circuit of 2 miles, with a fall of 5 ft. to the mile. For this reason it does not appear easy to exhaust the supply, as when the water is pumped out to 4 or 5 ft. from the surface of the well, it is replaced at a rate equal to the demand. Every allowance has been made for evaporation from the lake and pools, and the supply is regarded as inexhaustible. Another important fact here suggests itself; that is, that sufficient rain falls during the season in the area of 2 miles around the well to make the supply perennial. The Prospect Park well is a credit to Brooklyn.

Braced Arches and Suspension Bridges.—At a meeting of the Royal Scottish Society of Arts held at Edinburgh on Monday night, a communication was read on "Braced Arches and Suspension Bridges," by Mr. Jenkin, Professor of Civil Engineering in the University of Edinburgh. The Professor stated that the experiments made in connection with the Britannia Bridge had established the theory of metal girders on a sure practical basis, and with the inquiry of a Royal Commission into the application of iron to railway structures, had led not only to the general adoption of the iron girder a sa convenient type of bridge, but also to a widespread belief that essentially the girder is a cheaper and lighter form of support than the metal arch. The suspension bridge, indeed, the theory of which was identical with that of the arch, was known to be a lighter form of support than the girder; but an impression prevailed that the flexibility of the form could not be really overcome without sacrificing the lightness; and although this prejudice had been gradually yielding, the assertion that a stiff suspension bridge might be advantageously used for moderate spans would be received with doubt, while a statement that a cast-iron arch might not only be safely used for spans of 700 or 800 ft., but would be lighter than a girder for ordinary spans, would excite simple incredulity among practical men. Calculation showed that there was no essential superiority in the girder over the two other forms; but the adoption of braced arches and braced suspension bridges had been very materially retarded by the difficulty in making the necessary calculations as to the strains to the parts. In speaking of braced ribs, the Professor said the exact determination of the state of stress at different points became a problem of almost impracticable perplexity. He gave in his paper a method, founded upon a theory due to Professor Clark Maxwell, by which the necessary calculations could be made without extreme difficulty. These calculations had led to some novel and important results, showing a distribution of material in braced ribs or suspension bridges different from that hitherto employed. Thus, a chain of a braced suspension bridge, of a form which was exhibited in model, should be deeper at the middle to less than one-fourth of its cross section to the pier, and the bottom member also holding tension, should be increased in the ratio of 1 to 10 from the piers to the centre, where it should have nearly the cross section of the top chain at the pier. The arch should be designed with the same distribution of metal. Tables exhibiting the results of a comparison between arches and girders showed a great superiority in the arch or inverted arch. When a series of arches was designed, the thrust of one loaded arch could easily be provided for without greatly straining its unloaded neighbor. The paper was illustrated by models, one of which showed the perfect stiffness of a suspension bridge in which the top member was a chain, and the bottom member a straight tie parallel with the roadway. After discussion, the paper was referred to a committee.—*The Building News.*

Hell Gate—Proposed Canal through Astoria.—No one denies the fact that great advantages would accrue to our coasting trade, if the obstructions at Hell Gate were removed, and a safe channel laid out, available at all times of the tide. The work of Prof. Maillefert has already lessened the dangers of navigation in that locality, and the Government is making an effort in this direction also—which, however, it is thought by many will involve a vast expenditure of money and extend over a period of many years. Mr. W. W. Vanderbilt, late Constructing Engineer of the Pacific Mail Steamship Company, has conceived a plan for excavating a canal through the promontory upon which Astoria stands, and thereby forming a straight course from the East River to the entrance of the Sound, thus avoiding the crooked and dangerous channel now used by crafts in entering the Sound from New York, and *vice versa.* At first glance this is a startling proposition; yet upon examination the plan appears not only feasible, but far more economical than any yet put forward. The work could be accomplished with certainty, regardless of tide and weather, and could be completed inside of two years, at an estimated cost of not exceeding $3,000,000. The channel proposed would be about 2,000 ft. in length, 600 ft. in

breadth, equal to the width between Blackwell's Island and the Long Island shore, and with a depth at low tide of 34 ft., so that vessels of any draft and tonnage could pass through at all times of tide, and by night as well as day, in perfect safety. The point cut off from the main land could be appropriately used for the storage of petroleum and like inflammable stuff, or for a variety of other purposes. It is true, as the scheme now stands, the canal would strike through some valuable property; still the general plan is not incapable of modification by shifting the channel further to the westward, so as to bring it in line with the westward channel of Blackwell's Island, and then removing the extreme end of the promontory, around which at present the water rushes with mill stream velocity. The plan has many good points. Some of the most intelligent of the Hell Gate pilots who have seen the drawings, speak openly in its favor, and many engineers and practical men also indorse it. As yet no carefully prepared estimates have been made, nor comparison with the proposed work of Gen. Newton, the United States Engineer; but it is safe to say that the cost of the Government work would be double, if not treble, that of Mr. Vanderbilt. Parties are looking into the matter with a seriousness that indicates a possibility that something may yet be done in this locality which will be of enduring benefit to our marine interests, and at a reasonable cost.—*Gas Light Journal.*

A Ship Canal across Cape Cod.—We learn that a party of capitalists of ample means have organized their resources for the purpose of constructing a ship canal across Cape Cod, a project that has been much discussed, but which has never before assumed a practical shape. It is contemplated to build the canal in nearly a direct line from Buzzard's Bay to Cape Cod Bay, through a narrow neck of land separating those waters, which shall afford a sufficient depth of water to float the largest class of vessels. The canal will be 300 ft. wide, and deep enough to insure 24 ft. of water at low tide. A company has been formed to carry out the enterprise, the land surveyed, and other preliminary measures taken, and they now only await a charter from the Legislature for requisite authority to commence the undertaking. It is stated that the persons who propose to achieve this important work are fully prepared to carry it out, and ask for no pecuniary aid from the State in furtherance of the object. The great value of the proposed canal to the commercial interests of Massachusetts will undoubtedly commend it to public favor, as the importance of such a work has often been shown during the past few years.—*Boston Journal.*

NEW BOOKS.

The Midnight Sky—Familiar Notes on the Stars and Planets. By Edwin Dunkin, F. R.A.S., of the Royal Observatory at Greenwich. London: Religious Tract Society. 1869. For sale by D. Van Nostrand.

Although this work can in no way be considered as a rival to Mr. Proctor's excellent Star Maps, it is nevertheless one which must take a high rank of its own, and which appeals especially to the lover of popular science. It is certainly one of the best things which the Religious Tract Society has ever published, and we congratulate the Society on the fact. The author has sought to produce a general treatise on astronomy which shall at the same time contain a series of star maps useful to the amateur; and he has succeeded very well in his efforts. The ample quotations we have already made from the work elsewhere will be sufficient to show our readers the character of the book, and the clearness of Mr. Dunkin's style. But they cannot gather from them the character of his star maps, which is indeed somewhat peculiar. His aim has been to depict the sky just as a Londoner would see it during the various months of the year; and his method of execution, though not rigidly scientific, is still enough so for all practical purposes, and it has the great merit that it can be studied and understood, even by the most uninitiated. Indeed, one who knew nothing at all of astronomy could, in the course of a few bright nights, become familiar with all the constellations from this handsome volume. Let us take the first four illustrations as an example. Here we have two quarto plates. On the upper part of one is represented on a black ground the midnight sky of London, looking north, as seen on January 15. The stars are not named in the illustration, but below it is a small key or index map which enables the observer at a glance to find out the stars of greater magnitude. The second plate shows us the midnight sky of London, looking south, for the same date. In the lower part of each plate are shown the characteristic buildings, scenery, etc., of the locality from which the astronomer is supposed to take his observations. Thus, in the first we see St. Paul's and the different structures which lie in its neighborhood; and in the second, the Royal Observatory and the Hospital of Greenwich stand prominently forward. Pursuing this plan, the author deals thus with every month in the year, and furnishes, as we have said, a simple and intelligible series of star maps, which are described with some minuteness in the text.

Having treated in this way of the midnight sky as seen in the northern hemisphere, he next passes on to the sky of the southern hemisphere, and deals with it in an equally liberal spirit. Then follow the accounts of the constellations, considered independently, and of the Sun, Moon (including eclipses), the terrestrial planets, the Earth, the planetoids and the major planets, comets, and meteors; and lastly, a short chapter on Astronomy and the Bible. In all his descriptions the author is clear and popular, and not inaccurate; and for these reasons we have pleasure in recommending the work. The chapter on Biblical matters is the only one to which we object; we presume its introduction was unavoidable, but we must say that, however well intentioned, it is creditable to neither the author nor Modern Astronomy.—*Scientific Opinion.*

The Strains on Structures of Iron-Work. With Practical Remarks on Iron Construction. By F. W. Shields, M. Inst. C. E. Second edition. London: John Weale, 1867. For sale by D. Van Nostrand.

The methods of computation in this work are arithmetical, but are sufficiently comprehensive for the varieties of bracing discussed.

The Warren girder receives its full share of attention.

The Bowstring girder, with and without vertical struts, as well as the forms of bracing most

frequently applied to iron roofs in this country, are treated in a manner which requires no familiarity with the higher mathematics to comprehend.

The practical remarks on Iron Construction are too brief to be of much value.

Five well-executed plates illustrate the work.

THE SUN. By AMÉDÉE GUILLEMIN. From the French, by T. L. PHIPSON, Ph.D. London: Bentley, 1870. For sale by D. Van Nostrand.

M. Guillemin's work on "The Heavens," which was introduced to the English public some years since by Mr. J. Norman Lockyer, was so deservedly popular a book that, naturally, the present volume will be received with no little favor. But we fear that readers of "The Heavens" will be somewhat disappointed with "The Sun." Somewhat, we say; because, as a general treatise, it is not, in our opinion, to be compared to the earlier work. It must not, however, on that account, be imagined that the present volume is not a good one, and is not full of matter just now of especial interest to the educated public.

REPORT ON THE FILTRATION OF RIVER WATERS, for the supply of cities, as practised in Europe, made to the Board of Water Commissioners of the city of St. Louis. By James P. Kirkwood, C. E. 1 vol. 4to, 178 pp. and 33 Lithographed Engravings.—D. Van Nostrand, Publisher.

This subject, one but little understood with us, has received the most careful attention from the Engineer of the St. Louis Water-Works, Mr. Kirkwood, in an elaborate Report to the Commissioners of that work, published in a quarto volume with copious illustrations.

The water supply of an inland city must be sought for mainly in river water, with more or less inorganic impurities, which admit of ready separation by the proper means; what those means are, we have no precedent at hand for determining. It is in the experience of the oldest cities of Europe alone, that the data can be found to meet the future wants of our growing cities, and Mr. Kirkwood, after a careful examination of the prominent water-works of Europe, has given us the result of his labors, which will prove a standard work on the subject of filtration.

Although nominally a Report on Filtration, it at the same time embraces the characteristics of the various water-works examined, including the nature and extent of supply, the power used, and the nature of its application; fuel, consumption and cost; work done in water raised to a given height—in fact, all the details essential to the complete elucidation of the subject of water supply in the following localities: London, embracing Chelsea, Lambeth, Southwark, and Vauxhall Water-Works, Grand Junction, West Middlesex, New River and East London, Wakefield, Leicester, York, Liverpool, Edinburgh, Dublin, Perth, Berlin, Hamburg, Altona, Tours, Angers, Nantes, Lyons, Toulouse, Marseilles, Genoa, and Leghorn. The illustrations are very clear and precise, and the work fills a gap long existing in the literature of the profession of civil engineering.

AN INTRODUCTION TO THE SCIENCE OF HEAT, designed for the use of schools and candidates for University Matriculation Examinations. By TEMPLE AUGUSTUS ORME, Teacher of Chemistry and Experimental Physics, University College School, London. London: Groombridge & Sons. 1869. For sale by Van Nostrand.

The author discusses his subject in twelve chapters, and treats of Expansion and Conduction in Solids; Expansion, Conduction, and Convection in Liquids and in Gases; Evaporation and Liquefaction; Relative (or Specific) Heat; Nature of Heat; Connections between the Sciences of Heat and Chemistry; Radiation. We will try to include within our allotted space a word on the treatment of each of these subjects.

In the introductory remarks on Expansion the author puts himself the questions: "How is it that substances do not expand without being heated? and, How is it they do expand when heated?" and, of course, gives an answer to them. This he does by referring to cohesion as a force to be overcome by the heat. We are inclined to call this very old-fashioned teaching, and poor philosophy—quite out of place in a work so generally excellent as we find this little book to be. Our answer to the above questions would be: We do not know how; the facts are so, that is all we can say.

On conduction by solids, we find the author careful to be accurate in his teaching, and the same is true throughout the boook. We will here quote him:—

"If two similar bars, one of copper and the other of iron, are heated at one end, the opposite end of the copper bar will become hot long before the corresponding end of the iron bar. It is very natural to conclude from this that copper is a better conductor of heat than iron is; but it will be shown in a future chapter that this is by no means a logical conclusion."

It is afterwards pointed out to the student that the rate of transmission of heat depends upon the relative heat of the body as well as its conductivity.

Under expansion of liquids the effects of temperature on the height of the barometer, and the calculations they make necessary for the correct reading of the pressure of the atmosphere, are carefully considered; we think, however, there is room for a simpler treatment than it receives of this not very difficult subject.

Ventilation, atmospheric currents, relative weight (specific gravity) of gases and vapors (and the methods of taking it) are included and clearly described in the chapter on expansion of gases. The chapters on evaporation and liquefaction are also to be commended; they of course, include an account of latent, or, as it is here called, potential, heat, and the tension of vapors.

The difficulties generally felt by the student in mastering the subject of specific or relative heat will, we think, be found to be almost entirely removed, in consequence of the methodical treatment it here receives. The chapter on the nature of heat is an account of the reciprocal convertibility of heat and mechanical force, and the conclusion from this fact, that "heat is a mode of motion." It says nothing, we are glad to add, of that subtle fluid, caloric, on which writers have been so fond of dilating. In the remaining chapter, radiation and absorption of heat and the diathermanency of bodies are described.

Mr. Orme's little treatise appears to us to be an excellent text-book, meeting a want, and we congratulate him on its production.—*Scientific Opinion.*

WEISBACH'S MECHANICS: A Manual of the Mechanics of Engineering and of the Construction of Machines, with an Introduction to the Calculus, designed as a text-book for Technical Schools and Colleges, and for the use of Engineers, Architects, etc., by JULIUS WEISBACH, Ph.D., Oberbergrath and Professor at the Royal Mining Academy at Freiberg; Member of the Imperial Academy of Sciences at St. Petersburg, etc. In 3 vols. Vol. I., Theoretical Mechanics, with 902 wood-cuts in the text. Translated from the fourth augmented and improved German edition, by Eckley B. Coxe, A. M., Mining Engineer. 1,112 pages, 8vo. New York, 1870. D. Van Nostrand, Publisher.

An English translation of the first edition of this work, published in two volumes over twenty years ago, though poor as a translation, has yet been so extensively used, and of late commanded so high a price, as to show conclusively the very great excellence of the work itself in the estimation of teachers and engineers. All who have known either the original or the translation named, will be glad to learn that the new translation, the first half volume of which is now before us, besides being made from the fourth greatly enlarged and improved German edition, is also, as a translation, a great improvement on the old one, and, in some respects, is an improvement on the original itself, being made under the author's sanction, and embodying the latest corrections of both author and translator. This part, issued in advance of the complete volume, to meet the immediate demand for it as a text-book, includes the four sections: 1, Simple Motion; 2, Mechanics, or the Physical Science of Motion in general; 3, Statics of Rigid Bodies, and 4, the Application of Statics to the Elasticity and Strength of Bodies; together with a preliminary introduction to the Calculus. The use of the Calculus in this edition has involved the recasting of large portions of the work, as, especially, in the fourth section of this part. The entire work will, like the original, fill three octavo volumes of ten or twelve hundred pages each. Though too extensive, perhaps, and difficult for many besides special students and professional engineers, it will still, we hope, meet with such favor as to remunerate the enterprising publishers for undertaking to place before the country this invaluable Thesaurus of Theoretical and Applied Mechanics.—*American Journal of Science and Art.*

MISCELLANEOUS.

NEW THERMO-ELECTRIC PILE OF M. MURE & CLAMOND.—This thermo-electric pile, because of the intensity of the current and its economy, can be usefully employed in divers applications. It is made up of 60 elements. These consist of small bars of lead, or native sulphuret of lead, and of plates of steel. The bars are 40 millimetres long by 8 thick, and the plates of steel are 55 millimetres long by 8 broad, and 0.6 thick.

In these couples galena is the electro-negative element; iron, the electro-positive. The form of the bars is such that by placing them side by side, they form a ring of 12 couples, of which the interior is formed by the extremities which are to be heated. They are united in tension by means of tin solder. They are isolated from one another by thin mica plates. By placing 5 of these rings in a vertical column, a battery of 60 couples is formed. These rings are isolated and separated by washers of asbestos. The whole is firmly held between 2 iron rings by means of 3 bolts.

The pile thus forms a hollow cylinder, the interior of which must be heated. The cooling of the junctions, whose temperature should be lower, is caused by radiation into the air. The interior cylinder measures 50 millimetres in diameter and about the same in height. The heated surface is about 78 sq. centimetres. The apparatus is heated by a gas burner, consisting of a steel cylinder 55 millimetres in diameter, closed above, open below, and pierced with small orifices. This is placed in the centre of the pile. A tube pierced with holes surrounds this cylinder and distributes the gas uniformly around it. The gas rises, and arriving at the orifices in the burner, meets the air which is escaping from it because of the draft of the tube of steel that surrounds the apparatus. Each orifice in the burner thus forms a blowpipe, the jet of which strikes the opposite side.

Forty couples have an electro-motive force equal to that of a Bunsen element. Its interior resistance to cold is that of a copper wire 9.85 millimetres, and 1 millimetre in diameter. But during its action, it increases and becomes equal to 22 metres. The current is intense in proportion to the feebleness of resistance.

Visible sparks are obtained between the two electrodes. The current reddens a platinum wire 0.3 mil. in diameter a length of 35 mil. It also decomposes water.

This pile, acting for 10 consecutive hours, consumed 785 litres of gas, at an expense of 2 centimes and a half an hour. It is, therefore, an economical generator of electricity.—*Le Génie Industriel.*

MISSOURI TIN. About two years ago considerable interest was manifested in regard to the discovery of very extensive deposits of tin ore in this State, and land owners and speculators were accused of having the "Tin Fever." Weeks and months were spent by prospecting parties, and all the tin lands that could be purchased at reasonable rates changed hands. One company was organized, invested about $80,000 in tunnelling the hill and in work preparatory to the erection of a furnace. But their work has been stopped for several months—whether from want of capital, or energy and enterprise, we are not informed. Meanwhile, they have discovered tin ore in California, which is said to be inferior to the Missouri ore, and we now see by a California paper, that "The first article of tinware manufactured from tin mined in the United States has just been completed in San Francisco."

Numerous assays have been made of this ore by chemists and assayers of national reputation, who have repeatedly stated *here* that the ore will yield from 3 to 5 per cent. of pure tin; yet, when they reach the Atlantic cities, where the tin importers hold sway, they fail to find tin in paying quantities.

Chemical analysis, and assays are not wanted now; but, instead, we need a furnace to smelt the prepared ore and produce the pigs and bars of tin. A test furnace need not be very expensive, and this question, if decided affirmatively, will be of the greatest importance to this city, State, and the whole nation, as the importation of foreign tin into the United States now amounts to from five to six million dollars annually, and is constantly increasing. Who can say that the practical investigation of this subject will not prove as satisfactory as the experiments in smelting iron with our native coals?—*The Iron Age.*

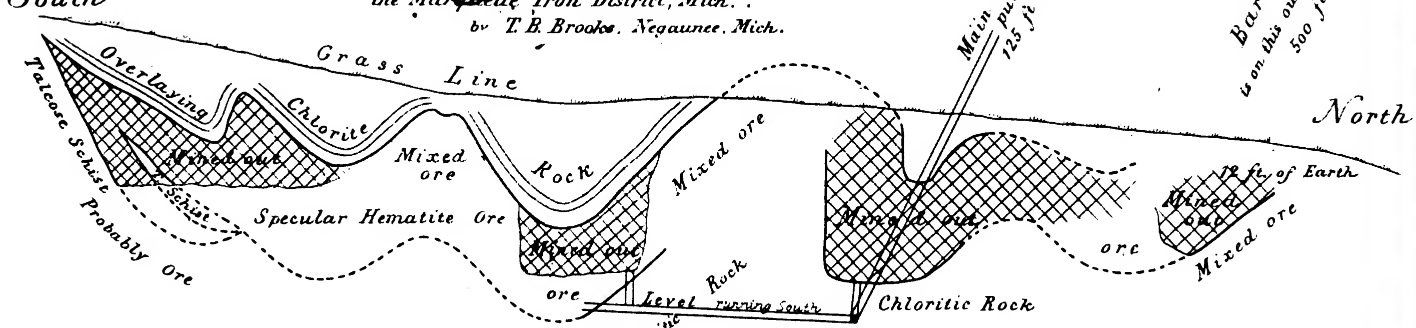
MARQUETTE MINING REGION. (p. 289)

The so-called "Hematite" (Limonite) bed, is about 400 feet South of South side of Mine, resting on the underlying "Greenstone."

Sketch (part ideal) showing N. and S. section through Lake Superior Mine, about 150 feet West of new Engine House.—

Made Jan. 1869 to illustrate "Notes on Geological Structure and modes of working the Iron Ore Deposits of the Marquette Iron District, Mich.".

by T. B. Brooks, Negaunee, Mich.



Explanation. *The full lines are actual; — the dotted lines are conjectural. "Mixed ore" means pure specular hematite, inter-laminated with quartz; some times the quartz is broken up so as to approach a breccia. The total length of Section that is, width represented on sketch as underlayed by ore, is less than 600 feet, which, so far as known, is the total width of the "hard ore" belt at this point. The axes of the folds, shown on this section, incline to the West. These axes sometimes undulate so abruptly, as to produce forms approaching a hemisphere, and in some instances "ear shaped" basins. From bottom of main shaft, levels running S. and E. found ore on all sides, but levels running West and N.W. found no ore.*

Engraved for Van Nostrand's Engineering Magazine, 1873

VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

No. XV.—MARCH, 1870.—Vol. II.

THE BESSEMER PROCESS UNDER PRESSURE.

From "Engineering."

It has long been known to Bessemer steel manufacturers that certain of the purer qualities of Swedish pig-iron, made with charcoal, and also some of the less

FIG. 1

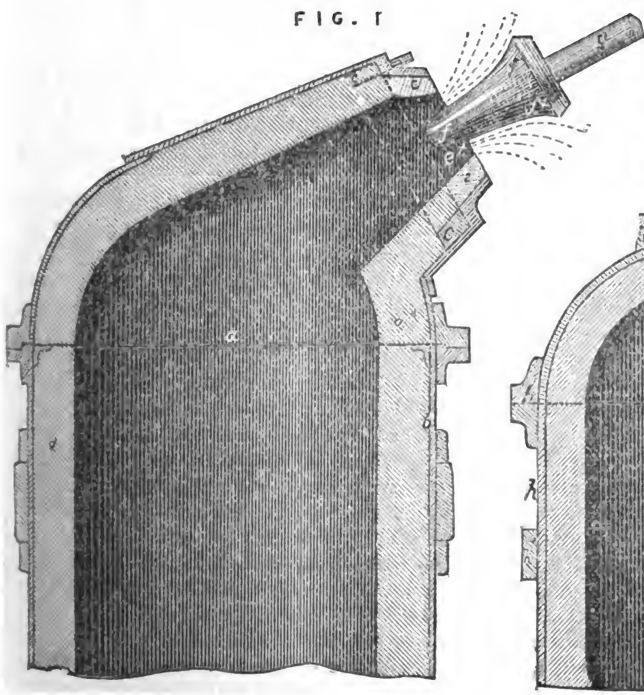
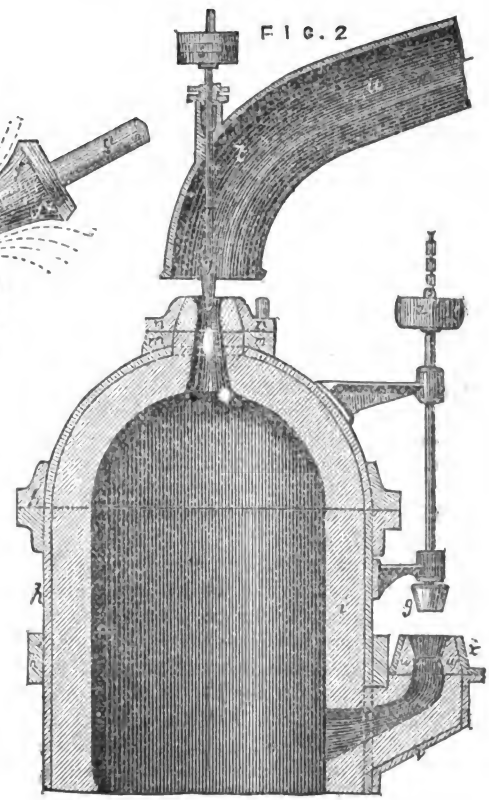


FIG. 2



gray and the white hematite pig-irons of this country, when treated by the Bessemer process, do not produce sufficient heat in the converting vessel, under ordi-

nary circumstances, to allow all the steel made from them to retain complete fluidity until it is poured into moulds, and hence it sometimes happens that large "skulls" or shells of solidified steel are left in the casting ladle. This evil is increased when malleable scrap-iron, or steel in a solid state, is added to the charge of metal in the converter.

To obviate this inconvenience, and to raise the temperature of the metal during the process of conversion so high that no skull or solidified metal shall be left in the casting ladle when employing carburets of iron not rich in graphitic or other carbon, Mr. Bessemer has lately schemed and patented the method of conducting his process under pressure, which we are about to describe—this method enabling the manufacturer to use many qualities of iron that do not produce a maximum of heat under the ordinary converting process, and also enabling him to put into the converting vessel a portion of steel scrap or scrap iron, or other kinds of decarburized or malleable iron in a solid state; which, by means of the extremely high temperature imparted to the metal, become fused and form part of the charge of molten malleable iron or steel obtained. For this purpose Mr. Bessemer makes the converting vessel of great strength, securely riveting and caulking all the laps and joints so as to render it air-tight as near as may be; and he, by preference, forms the mouth of the vessel circular instead of oval, and of a smaller size than usual, lining the mouth with a single ring of well-burnt fire-clay or composition of clay and plumbago. He also forms the metal part of the mouth of the converter with a movable dovetailed flanged ring, so that the fire-clay mouth of the vessel may be readily taken out and renewed by unbolting or uncottering the iron ring which retains it in place.

In the annexed engravings, Fig. 1 is a vertical section of a Bessemer converter constructed on this plan, *a* being the upper part of the converting vessel; *a*×, the lining of ganister; and *b*, the strong riveted iron shell or vessel on the inside of the mouth of which the iron hood, *c*, is riveted; while *d* is a flanged iron ring, bevelled on the inside, and secured by screwed studs or cotter bolts to the hoop, *c*. A moulded ring, *e*, of fire-brick or other suitable refractory material, forms the escape opening or mouth of the vessel; it is retained in place by means of the flanged ring, *d*, and when it is worn out or damaged, the ring, *e*, may be renewed by unfastening the ring, *d*, a mixture of fire-clay and ganister being first smeared over those parts of the ring, *e*, which come in contact with the lining, *a**, and with the bevelled interior of the ring, *d*, for the purpose of making the joint air-tight.

The aperture in the movable mouth of the vessel thus formed may in some cases be made small enough to retain the gaseous products resulting from the combustion of the carbon or other matter contained in the pig-iron under a pressure much above that of the surrounding atmosphere, so that the combustion going on in the converting vessel may be under "high pressure," as described in our account of Mr. Bessemer's new melting furnaces, which appeared on pages 187 and 197 of our last volume. The contraction of the mouth of the vessel would in this case be greater than is shown in Fig. 1 for the purpose of retaining the gaseous products under considerable pressure, so that the gaseous products resulting from the combustion of carbon and other matters in or among the fluid metal would be prevented from expanding freely; and by reason of the combustion so taking place under a pressure much greater than that of the external atmosphere, a more intense heat would be produced and imparted to the metal.

The amount of pressure thus obtained should vary with the heat producing properties of the carburet of iron operated upon and the quantity of scrap or other unfused metal forming part of the charge, so that no precise rule can be laid down as to the pressure to be employed; but as a guide to the workmen, Mr. Bessemer states that for the conversion of the purer kinds of Swedish charcoal pig-iron and for mottled or white hematite pig-iron mixed with gray, a back pressure in the vessel from 8 to 15 lbs. on the square inch will give good results, and in but few cases will a pressure of 20 lbs. per square inch be necessary; while a pressure as low as 3 or 4 lbs. will be but of little practical advantage, and below 2 lbs. per square inch he lays no claim to as a useful effect. It will be understood that the pressure of the blast of air forced into the converting vessel must be increased in

proportion to the back pressure caused by the penning up of the gases within the vessel.

Mr. Bessemer, however, remarks that the mode of obtaining the required back pressure by simply diminishing the outlet does not offer all the desired facility of regulating the pressure from time to time during the process, while at the same time the accumulation of slags in the aperture may in some cases reduce the area of outlet so much as to retard the inflow of air through the tuyeres. For these several reasons the opening in the mouth of the converting vessel may be made much too large if left open to retain the gaseous matters in the converter at the high pressure desired, such larger sized mouth being provided with a conical stopper inserted in the opening and so arranged as to be advanced or further withdrawn by being itself movable or by the motion of the vessel on its axis, the vessel being made to advance towards or recede from a fixed conical stopper. Mr. Bessemer, however, prefers to use a movable conical stopper attached to the end of an iron rod, as shown in Fig. 1. The conical piece of fire-brick, *f*, is circular in form, and spreads outward in a curved line at *f**, for the purpose of deflecting the flame and preventing its too powerful action on the iron rod, *g*, which supports the cone, *f*. The rod, *g*, protrudes through the back wall of the converting house, or may be supported on a bracket or piece of iron framing in connection with the standards which support the vessel, and by means of a screw or lever, the cone, *f*, is made to advance further into or recede from the mouth of the converter, thus increasing or diminishing the area of the annular opening at *e**, and regulating the pressure of the confined gases in the vessel.

In some cases it may be found desirable to render the stopper, *f*, self-acting by applying a spring or weighted lever to press it forward against the pressure of the escaping gases, so that, either by reason of its enlargement by the accretion of slags on its surface, or by being partially burned away, it will occupy such a position in the mouth of the vessel throughout the process as will give a sufficiently equal amount of back pressure, and prevent that pressure from exceeding what is necessary by any partial clogging up of the escape opening; or in lieu of employing a conical stopper, a flat or other shaped surface may be employed, the object in either case being to enlarge or contract the opening for the escape of flame as found desirable at different stages of the process. The pressure of the confined gaseous products is indicated by a mercurial column arranged as described on page 15 of the present number. This gauge will allow the workman to employ from time to time such an amount of internal pressure in the vessel as the known qualities of the material he employs may render necessary.

When crude molten iron or remelted pig or refined iron is decarburized or partially decarburized or converted into refined iron or into malleable iron or steel by the action of nitrate of soda or potash, or by other oxidizing salts, or when such decarburation or conversion is effected by any other processes in which the decomposition of nitrate of soda or potash, or other oxygen-yielding salts alone or mixed with metallic oxides, takes place in or below the fluid metal in a converting vessel or chamber, a large amount of heat is absorbed and rendered latent, thus tending to solidify the metal and rendering it unfit for forming into ingots or castings without being remelted.

To obviate this and raise the temperature of metal (while so treated or converted) to such a degree as to allow it to be cast into ingots or other cast articles or masses prior to its solidification, Mr. Bessemer proposes to construct the vessels in which the process is to be carried on of great strength, preferring to use stout iron or steel plates well riveted and caulked, and, if needful, further strengthened by stout hoops. The mouth of the vessel is to be made very small, Mr. Bessemer preferring for that purpose to employ a well-burned fire-brick ring, into which a long taper cone of the same material is placed. The cone is fastened to a long rod working in suitable guides, so as to keep it central with the mouth of the vessel. The space between the exterior of this cone and the interior of the fire-clay ring determines the area of outlet for the gaseous products given off during the time that the decomposition of the nitrate or other oxygen-yielding materials is going on, and a weight or spring lever, acting on the rod to which the fire-clay cone is attached may be made to regulate the

amount of pressure required to lift the cone and permit the escape of the gaseous matters.

The arrangement of which we have just spoken, is illustrated in Fig. 2, which represents a vertical section of the upper portion of a converting vessel or chamber in which molten pig or other carburet of iron is to be treated either by the injection of the fluid nitrate into the molten metal, as patented by Mr. Bessemer in March last, or in which vessel the nitrates or other oxygen-yielding salts or substances are so brought into contact with the hot metal as to be decomposed. The outer shell, *h*, of the vessel or chamber, is made of thick plates of iron or steel, securely riveted and caulked at all joints, and capable of withstanding safely a pressure of from five to ten or more atmospheres. For the convenience of lining the vessel, the upper part may be removed by unbolting the stout flanges, h^1; and one or more hoops, h^2, are riveted to the exterior of the vessel to strengthen it. A lining of fire-brick, ganister, or other refractory material, *i*, is used to defend the outer shell from the high temperature generated within; and previous to its use for conversion, Mr. Bessemer prefers to make a fire in the interior so as to highly heat the lining and lessen its power of absorbing heat from the metal.

On the upper part of the dome an iron ring, *m*, is riveted, to which a flanged ring, *n*, is fitted. The inside of this ring is conical and is made to embrace the conical fire-clay ring, *p*, through which the gaseous matters evolved during the process are allowed to escape. A cone of fire-clay or of iron, *g*, is attached to the guide rod, *r*, for the purpose of closing or diminishing the area of the outlet opening in the fire-clay ring, *p*, and on the upper end of the rod, *r*, are placed weights, *s*, to regulate the pressure. The rod, *r*, is guided vertically upward and downward by passing through the tubular guides and stuffing-box formed at *t t*, on the curved exit passage, *u*, which leads to a chimney and conveys away the gaseous products escaping from the converting chamber. On one side of the vessel or chamber is a projection, *v*, on the upper part of which a ring of fire-brick, *w*, is retained in place by a conical flanged iron ring, *x*. The opening in the ring, *w*, serves for the admission of the molten metal to the vessel, after which the cone, *y*, smeared with fire-clay, is lowered down into the opening of the moulded fire-brick, *w*, and by means of the weight, *z*, is retained in place and prevents the escape of gaseous matters during the converting process.

The cone, *y*, and its rod and weight, *z*, are suspended by a chain in the position shown during the period of running in the metal. When the metal so run in comes in contact with the nitrate or other oxygen-yielding materials, large volumes of gaseous matters are evolved, these matters, instead of escaping freely from the converter, rapidly accumulating in the vessel until the pressure within it is sufficient to raise the cone, *g*, and escape by the small annular opening thus made, the pressure being regulated by the weight, *s*. Hence the combustion of the carbon contained in the molten iron, by reason of its union with oxygen derived from the decomposition of the nitrates or other oxygen-yielding materials, will be effected under considerable pressure; and the gaseous products, instead of expanding freely as under the ordinary conditions of combustion, will be in a highly condensed state, by which means their temperature will be considerably raised, and the intense heat so generated will be imparted to the metal and cause it to retain its fluidity.

Dr. Mayer, the celebrated physicist, has now perfected an instrument he calls a dynamometer, which, adapted to engines of 20-horse power and upwards, reads simultaneously measurements of force in the form of heat as well as of pressure. We have no account as yet of the instrument, which is obviously of more scientific than practical value. The same philosopher, dealing with the question of the conservation of force, has come to the conclusion that the large amount of force which is lost in the form of heat in all mechanical operations can never be utilized. Heat, he tells us, is the cheapest possible form of force, mechanical is far dearer, and electricity the dearest force of all. Hence it would never pay to transform waste heat into any other form of force.—*Mechanics' Magazine.*

In exploring the caves at Wellington, N. S. W., the remains of various extinct animals have been discovered.

ON THE LABORING FORCE OF THE HUMAN HEART.

From "Nature."

There is no organ in our bodies that has a more important influence upon health, at all ages of our lives, than the heart, whose rhythm and force are governed by laws of nerve force, of which we are at present almost totally ignorant. Regarded, however, from a mechanical point of view, as a hydraulic pumping machine, our knowledge of the heart is more accurate, and may yet lead the way to greater knowledge of the physiological action of this vital organ.

I propose, in the present communication, to give an estimate of the daily laboring force of the human heart, and to compare it with that of other muscles, such as those used in rowing or climbing, reserving for a future communication the proof of the data to be now employed.

The heart, regarded as a pumping machine, consists of two muscular bags (*ventricles*), one of which drives the blood through the lungs, and the other through the entire body. This blood is forced by a pumping action, repeated seventy-five times each minute, through both lungs and body, and experiences in each case a resistance which is measured by the hydrostatical pressure of the blood in the pulmonary artery and aorta. The resistance offered to the circulation of the blood by the capillary vessels of the lungs and body, is different; but the total quantity of blood that passes through the lungs and body in a given time must be the same; from which it follows, that the resistance offered by the capillaries must be in the proportion of the hydrostatical pressure in the great arteries leading from the ventricles of the heart. If, therefore, we knew that pressure for one side of the heart, and the relative forces of the two ventricles in contracting, we should know the entire resistance overcome by the heart at each of its beats.

If, in addition to the hydrostatical pressure in one ventricle, and its ratio to that in the other ventricle, we knew also the quantity of blood forced out of each ventricle against this pressure, we should have all the elements necessary to calculate the laboring force of the heart, as will be presently shown.

I demand, therefore, that my reader shall grant me, provisionally, the following postulates, which are necessarily three in number:

I. That three ounces of blood are driven from each ventricle at each stroke of the heart.

II. That the hydrostatical pressure in the left ventricle and aorta, against which the blood is foced out, amounts to a column of blood 9.923 feet in vertical height.

III. That the muscular force of the left ventricle, in contracting, bears to that of the right ventricle the proportion of 13 to 5.

With these postulates granted, we may now proceed to calculate the daily laboring force of the heart as follows: At every stroke of the heart, three ounces of blood are forced out of the left ventricle against a pressure of a column of blood 9.923 feet in height. The work done, therefore, at each stroke is equivalent to lifting three ounces through 9.923 feet. This work is repeated 75 times in each minute, and there are 60×24 minutes in the day. Hence, the daily work of the left ventricle of the human heart is $3 \times 9.923 \times 75 \times 60 \times 24$ ounces lifted through one foot; or since there are 16 ounces in the pound, and 2,240 lbs. in the ton, the work done by the left ventricle of the heart in one day is $\frac{3 \times 9.923 \times 75 \times 60 \times 24}{16 \times 2,240}$ tons lifted through one foot. Multiplying and dividing out this quantity, we find the daily work of the left ventricle is 89.706 foot tons. The work done by the right ventricle is five-thirteenths of this quantity (post. III.); the daily work of the right ventricle, is therefore 34.502 foot tons. Adding these two quantities together, we find for the total daily work of the human heart 124.208 tons lifted through one foot.

It is not easy for persons unaccustomed to these calculations to appreciate quickly the enormous amount of laboring force denoted by the preceding result; but in order to facilitate this appreciation, I shall compare it with the following descriptions of labor:—

1. The daily labor of a working man.
2. The work done by an oarsman in an eight-oar boat race.

3. The work done by locomotive engines, or animals climbing a height.

1. The daily labor of a working man, deduced from various kinds of labor, from observations spread over various months, is found to be equivalent to 354 tons lifted through one foot, during the ten hours that usually constitute the day's work. This amount of work is less than three times the work done by a single heart, beating day and night for 24 hours: thus, three old women sitting beside the fire, alternately spinning and sleeping, do more work by the constant beating of their hearts, than can be done in a day by the youngest and strongest "navvy."

2. If an Oxford eight-oar boat be propelled through the water at the rate of one knot in seven minutes, the resistance offered by the water may be estimated at 81.36 lbs. by calculation, or at 74.15 lbs, by actual observation. From this result, and from the fact that 575 ounces of muscle are employed by each of the eight oarsmen, we can calculate that 15 foot-pounds of work are expended by each ounce of muscle during each minute of work.

No labor that we can undertake is regarded as more severe than that of the muscles employed during a boat race; and yet this labor, severe as it is, is only three-fourths of that exerted day and night during life by each of our hearts.

The average weight of the human heart, which increases with age (for obvious reasons), may be estimated from the following tables:

	Average oz.
1. Meckel	10.0
2. Cruveilhier	7.5
3. Bouilland	8.4
4. Lobstein	9.4
5. Boyd (æt. 30—40)	10.4
6. Boyd (æt. 40—50)	10.5
Mean	9.39

From this weight, and the work by the heart in one day (124 foot-tons) we can calculate the work done by each ounce of the heart in one minute, as follows:

Work done by the human heart, in foot-pounds per ounce per minute,

$$\frac{124.208 \times 2240}{9.39 \times 24 \times 60} = 20.576 \text{ foot-pounds.}$$

This amount of work exceeds the work done by the muscles during a boat race (as already stated) in the proportion of 20 to 15, or of 4 to 3.

3. There is yet another mode of stating the wonderful energy of the human heart. Let us suppose that the heart expends its entire force in lifting its own weight vertically; then the total height through which it could lift itself in one hour is thus found, by reducing the daily work done in foot-tons (124.208) to the hourly work done in foot-ounces, and dividing the result by the weight of the heart in ounces:

Height through which the human heart could raise its own weight in one hour =

$$\frac{124.208 \times 2240 \times 16}{24 \times 9.29} = 19754 \text{ ft.}$$

An active pedestrian can climb from Zermatt to the top of Mont Rosa, 9,000 feet, in nine hours; or can lift his own body at the rate of 1,000 feet per hour, which is only one-twentieth part of the energy of the heart.

When the railway was constructed from Trieste to Vienna, a prize was offered for the locomotive Alp engine that could lift its own weight through the greatest height in one hour. The prize locomotive was the "Bavaria," which lifted itself through 2,700 feet in one hour; the greatest feat as yet accomplished on steep gradients. This result, remarkable as it is, reaches only one-eighth part the energy of the human heart.

From whatever mechanical point of view, therefore, we regard the human heart, it is entitled to be considered as the most wonderful mechanism we are acquainted with. Its energy equals one-third of the total daily force of all the muscles of a strong man; it exceeds by one-third the labor of the muscles in a boat race estimated by equal weights of muscle; and it is twenty times the force of the muscles used in climbing, and eight times the force of the most powerful engine invented as yet by the art of man.

No reflecting mind can avoid recognizing in its perfection, and regarding with reverential awe, the divine skill that has constructed it.

The most powerful fog-whistle in America is at Cape Fourcher, N. S. It can be heard 15 miles in clear weather and 25 with the wind.

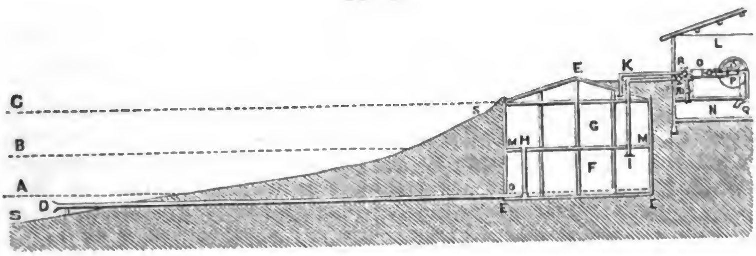
THE TIDE-MOTOR.

Condensed from "Annales de Genie Civil."

An Italian engineer, M. F. Tommasi, has just patented in France and elsewhere a Motor, called Le Flux Moteur, which uses the fall of the tide as a motive power. We give an abstract of the first chapter of the Memoir published by M. Tommasi, in which he explains the principle, construction, and application of his invention.

If the water of the sea is conducted into a reservoir by means of a horizontal tube set at the main level of low water at the spring-tide, the bottom of the reservoir being at the same level with the tube, and its top being at a level with the base of the *unit of height* of the tide (A B D F, Fig. 1), it is obvious that this reservoir will always contain water, and that its level, rising

Fig. 1.

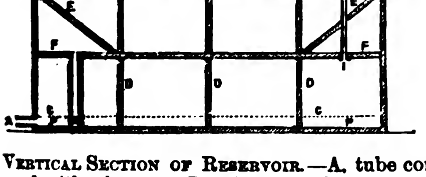


A, mean level of low water at spring-tide; B, base of *unit of height;* C, mean level of high water at spring-tide; F, lower reservoir; G, upper reservoir; H, pipe to upper reservoir; I, pipe to motor apparatus; K, pipe connecting with discharge pipe of motor apparatus; MM, horizontal partition; N, storage reservoir; O, cylinder; P, pump.

with the sea, will be at its extreme height when the sea is at the mean of its ascent; provided that there is a suitable orifice of discharge for the air which fills the reservoir, so that it can escape when the water enters.

But if, on the contrary, this reservoir is closed, the enclosed air, in preventing the water from rising, will suffer a pressure proportional to the relative height of the sea. It follows that, by connecting the upper portion of the reservoir with a motive apparatus, by means of a tube, the

Fig. 2.



Vertical Section of Reservoir.—A, tube connected with the sea; B, pipe carrying water to upper section; C, minimum level; D, E, frame; F, horizontal partition; I, pipe to motor apparatus; K, pipe connecting with discharge pipe; M, manometers; N, tubes connecting the several reservoirs.

piston will be driven with a force proportional to its area and the tension of the air; a tension proportional to the weight due to the charge of sea water. By making the area of the piston proportional to the work required, and the tension of the air at the time the level of the sea has reached a certain point, it will result that from this point to the limit of the flood height, the piston will always move with the same force; since the reservoir level rises with the sea level; and, the difference always being the same, the pressure of air and the work resulting will be constant.

If, during the operation of the motor, the water from the sea freely enters a reservoir placed above the other, having its upper surface at the height of spring-tide (C H M, Fig. 1); and if the plug is closed, when this reservoir is filled, the ebb will leave it full of water, and when the sea has sunk so far that, relative to its maximum level, it has the same head as it had at first relative to its mimimum level, the work of the water suspended in this reservoir is equal to the work of the sea-water when it had risen to the given point. Now, by connecting the upper portion of the reservoir by means

of a tube with the discharge pipe, the external air, in entering, will drive the piston with a force proportional to its area, and to the rarefaction produced on the other side by the weight of the descending water. Since this weight is equal to that which has compressed the air in the other reservoir, it is equal to the pressure of the external air. From this time to the end of the reflux, the piston will move with the same force, since reservoir level and sea level descend alike; and the difference being constant, the pressure of the air, and hence the power generated, will be constant.

Now, if before the work ceases, which happens when the upper reservoir is empty, the valve at the upper portion of the lower reservoir communicating with the air is opened, the water will descend with the sea level. When the tide rises, the valve is closed, and the operation is repeated.

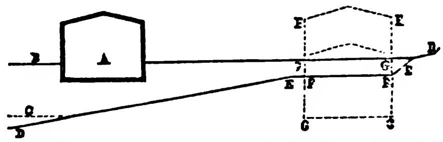
In using the apparatus described above, each period of work must be followed by one of repose. The hours of work vary with each day; and hence the motor is suited to those industries only in which it is not necessary to have steady power; for example in machines for raising water, saw-mills, etc.

When steady power is desired, the apparatus is modified. Another reservoir is added as a storage reservoir (cloche de réserve), and pumps are used to condense air. This is operated when men are off work (as in the night and on Sunday); and by means of these pumps it fills the storage reservoir with condensed air. If the tide has not reached a point suitable for direct application of its work, power can be obtained from this form of the tide-motor by stopping all of the pumps and one of the cylinders, and making connection with the storage reservoir. This will furnish condensed air for work until the tide has turned so as to furnish its power direct.

The reservoir is of wood, braced with oak and securely hooped. Its wall is of pitch-pine plank, and saturated with tar. The height of the cylindrical portion should be about half a metre more than twice the height of the *unit of tide*. The horizontal partition should be half a metre above the middle of the cylinder.

The diameter theoretically depends upon the amount of pressure required; but it would be convenient to establish a constant diameter of say 20 metres; as this gives great capacity without difficulty of construction, and the fixed dimensions would cheapen future constructions.

FIG. 3.



A, reservoir ; B, level of high water ; C, level of low water ; F, reservoir set at high tide above its bed ; G, final position of reservoir.

When the reservoir is finished it is launched, and towed to its station. A bed, E, 23 metres wide, starting at the level of the highest tide, and extending toward the sea, so far that its lower level is horizontal, is dug in the sand, to a depth equal to the draught of the reservoir. This should be dug at ebb tide. At flood the reservoir is moved to its place, F. At low tide a trap is opened in the ceiling, workmen descend, and, taking up the floor (not yet fastened), pass out the sand toward the sea side so that the reservoir becomes firmly fixed. When the base has reached the point G, the flooring is replaced and calked.

A trench is now dug seaward, half a metre below mean low-tide level, in which is laid a red cedar pipe, bound with wire hoops, gutta-percha-coated, with joints of oak. This tube is so disposed that the sea end is above the bottom; but it is never out of water, so that the sand cannot choke it. Notwithstanding this precaution, should this happen, the slight inclination will cause the tube to be scoured out at each ebb; or the reservoir can be discharged for this purpose.

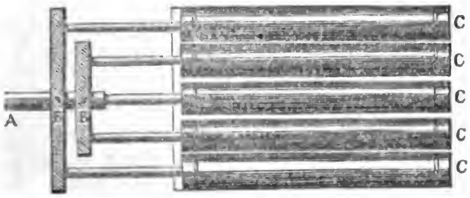
The pipe, being set, is covered with sand; the planks of the horizontal partition are set and calked; the vertical tube from the upper chamber is placed; the reservoir is closed hermetically; connection is made with the motive apparatus, and the motor is ready to do work.

Certain peculiarities of construction in the motive apparatus are necessary. (1.) The dimensions of the cylinder should be large, because of the low pressure on the piston. (2.) A regulator would obviously be useless. (3.) The stop-cocks are of a kind specially adapted for this purpose.

In order to transform the intermittent

motive-force into a continuous work, it is only necessary to have an air-tight storage reservoir large enough to furnish the motive power during the time when the tide cannot work directly.

FIG. 4.



B, Movable bolts. C, Cylinders.

The compresso-motor apparatus should have two cylinders. The piston rod should drive directly five pistons. The two cylinders of the motor-pistons and the ten pumps should be of double effect. Upon the rod of the two motor-pistons is fixed the cam for transmitting the motion to the crank. The fly-wheel for regulating the motion should be of great size and little weight. Each group of five pistons should be divided into two couples and one independent piston, so that the number at work can be regulated. Each pump should be supplied with two stop-cocks, by means of which, communication may be made with the storage reservoir or with the external air. The motor pistons should be set so as to be detached from the crank, so that the motive apparatus can be worked without the pumps. The apparatus will be more clearly understood by reference to the illustrations.

The inventor claims that the Tide-motor will, for obvious reasons, cheapen manufactured products; that the compressed air can be conveyed for use to great distances by means of pipes; that the power is uniform and constant; that it is free from danger; and that it affords the advantages sought for in attempts to invent a perpetual motion.

THE FAIRLIE ENGINE.

[The following, from a correspondent, is a timely answer to the inquiries of many correspondents concerning this engine.—ED.]

The readers of this magazine have seen, since its opening, numerous accounts of this locomotive, but perhaps some have not been aware that there was one building in this country. This has been constructed in the shops of Mr. Wm. Mason, Taunton, Mass., from original designs of Mr. Fairlie, Americanized by Mr. Mason. This engine is 56 ft. long, and has 12 driving wheels, with, therefore, a rest of 5 tons upon each wheel. Her boiler has the appearance of two ordinary locomotive boilers turned fire-box to fire-box. These fire-boxes being separate; the steam space, and such part of the water space as allows 6 inches of water to lie upon the centre of the crown-sheet (upon whatever grade she may be) being connected. Two smoke-boxes, two smoke-stacks, each at the end of the boiler; two steam domes, two safety-valves, two bells, etc., each in their usual place upon the apparent two boilers. In the centre, over the fire-boxes, is the cab. Inside this the throttle lever works horizontally in circular guides, upon a vertical axis, raising puppet valves in the steam domes simultaneously. It is placed on the top centre of the boiler, and is useful from both sides. A hand-wheel upon each side works the link. Levers duplicated work the sand-box and cylinder cocks. The blower-rods are doubled that the engineer may stand on either side of the boiler. The coal-breakers are four in number, two just outside each end of the cab. Upon the boiler and frame are securely fastened water tanks of sufficient capacity, which, though connected, contain 4 water holes.

Upon a simple cradle, formed of two long slabs, firmly bolted to the boiler, and two inverted saddles of cast-iron, the boiler rests. To the two saddles the centre pins are attached, working upon the centre of the truck with a ball and socket action. There are two other inverted saddles upon the frame, over that end of each truck which is nearest the fire-boxes, to which are attached bearing surfaces, which rest and slide easily upon surface bearings upon the ends of the trucks, with a side play of about 8 inches. There are elliptic springs upon each side of the centre pins, and volute springs to ease the bear-

ing surfaces upon the inside ends of the trucks. Three wheels, of 3½ ft. diameter, support each side of each truck, giving a wheel base of 8 ft. 3 in.

On the outside ends of each truck are two cylinders, with all their connections; each cylinder working the three wheels, two flanged and one bald; the latter is of course the centre wheel. These cylinders receive their steam from a pipe which passes vertically from the smoke chamber to a stuffing-box upon the top of the truck; from this stuffing-box another pipe with a hollow ball attachment within the stuffing-box, runs forward into a stove; from this stove another pipe passes still forward, with another hollow ball attachment in another stuffing-box. These balls work in the stuffing-boxes as rockets and in the stove by sliding. At the second stuffing-box, the steam pipe is divided, and passes through the casting, forming the front of the truck to the cylinders. The exhaust is handled in about the same manner. Other devices may be used for making the steam pipes flexible, but this seems to answer remarkably well in practice and to improve by use.

For expansion and reversion the sink is used; the fact, that in all angles the centre of the truck remains a fixed point, allows a fulcrum to be placed there with only one "knuckle-joint" to give ease to the rods, which handle easily. Pilots and brackets for head-sights are placed at each end, and she is always ready to start in either direction. As the tanks are so close, there is no need of an extraneous pump, the injectors answering every purpose; and as one sink is up when the other is down, the counter weight, or usual spring, is dispensed with. There are 4 fire-doors, and the blowers may be be put on from either side.

Counting her as one engine, she has nearly double the number of pieces as an ordinary locomotive, and is so much more complex. Counting her as equal to two, she is more simple in the frame, with less need of pumps and without necessity of counter weights. There are also four less wheels, with their axles, boxes, slides, springs, and equalizers. There is no tender to haul, the equivalent for it aiding her power by additional adhesion. Brakes are worked upon each truck from the cab.

The appearance is prepossessing, giving a greater idea of power than is presented by the old locomotive. The motion is exceedingly pleasant, consisting almost exclusively of rising and falling in long low curves, with no perceptible side oscillation. Indeed she appears to possess a wonderful faculty for keeping the centre of the track, or else of touching the rail so lightly and sheering off so smoothly as to leave her transverse motion unfelt. The same principle seems to apply to her passage over the ordinary cast-iron frog, and around several reversions upon turnouts of unknown but sensibly small radii. In all cases her motion was so peculiarly soft in comparison with that of the ordinary engine, as to suggest at once a considerable decrease in the item of repairs, both to rolling stock and permanent way.

Another peculiarity is the power she possesses of throwing her centre of gravity nearer to the centre of the curve in proportion to the shortness of the radius, thus counteracting the force tending to throw her outwards in somewhat the same manner as it is done by animate beings.

The writer of this article had gone to Taunton to examine the engine, and has spent some time studying her construction while she was being put together, and her action under steam. But there was still another desideratum. What would she do with a train of freight cars? The difficulty was to get cars enough upon the light grades around Taunton. For, if an ordinary Bajie engine of the same capacity of cylinder (15×22 stroke), could pull 30 8-wheel cars from Taunton to Mansfield, she should pull just 90; or, if the first could do a daily work of 25, she should do a daily work of 75. And 75 cars, much less 90, were not to be got together. The only way to do then was, to start her with the usual train (she has the masculine double-faced name of Janus), and judge her simply by her style of handling it. This was done on Friday, January 28. The load was equal to 26 cars (8-wheeled). Suffice it to say of an experiment, so far from what was to be desired, that they were handled easily on main track and switch with the valves cutting off at an allowance of 3 in. of steam, and a pressure never greater than 117, and mostly down to 82 or 85 lbs. Her consumption of coal seemed to be

economical, but circumstances did not allow of accurate tests.

Her easiness of management was fully tested, and was most satisfactory. Her power was not tested. On some of our mountain roads, where gradients and curvatures combine to produce resistance, her peculiarities could be fully developed and examined. We suggest this to some road. Mr. Mason has well done his part.

The writer, having had occasion to notice that the instance of the Fairlie engine "Little Wonder" upon the Festiniog Railroad, had apparently begot a mental connection in the minds of several well-known and intelligent engineers, between the Fairlie system and the very narrow gauges, begs to offer a few suggestions: The cheapening of the construction of roads by the adoption of this system would, for a time at least, be confined to branch roads. Although our knowledge of the economy with which narrow gauge roads (2 and 3 ft.) in Norway and other countries are run, is beyond dispute. We should remember that in this country it would be cumbered with the necessary unloading and reloading of freight at the junctions, and with, of course, an additional number of cars. Our late changes of gauge, though made in one direction, were not so much in deference to economy of running as to the economic convenience of connection. A car once loaded is paying in proportion to the distance it travels, and losing in proportion to every change in the position of its centre of gravity in any useless direction. Thus the benefit of the system might be fully counterbalanced, if after a haulage of 10, 20, or even 50 miles, this centre of gravity was lifted vertically and then set down upon another train. Then, without throwing aside advantages which might accrue from a narrow gauge, these principles might be safer to start upon. That if a Fairlie of 30 tons weight with 12 drivers, and therefore a weight of 25 tons upon each wheel, will traverse curves of say 300 feet radius, or less, at a fair rate of speed; iron may in the first place be purchased corresponding to the weight of wheel in goods wagons (also about 27 tons), instead of being arbitrarily determined by the 5, 6, or 7 tons driver weight of the present locomotive, so as to be either doubly heavy and costly or one half as lasting. The saving in graduation by the use of the above stronger curvatures would vary with the contour of the country, and might easily vary from 0 to 60 per cent. of the present cost. The saving in the raising and repacking of cross-ties would also be important; so would be the saving in engineers' wages, turn-tables, turn-table labor, and turn-table repairs and renewals. Further, by adding the steam car, and drawing less non-paying to paying load, thereby a still further reduction would be made in the expenses of small lines and short-distance accommodation trains. Altogether the system is eminently worthy of thought and experiment.

MISSOURI.

ART IN ENGINEERING.

From "The Building News."

Nothing is more curious in the history of Architecture than the way in which its various changes and different phases have succeeded each other. It would seem that these changes have followed each other in an almost, if not quite, insensible way, like fashion in dress; and this went on in quite a natural and regular manner though all the Gothic styles, from the earliest to the latest. It did so with the Renaissance and the older styles of architecture; but in these modern days, by a singular series of what may be almost termed accidents, this natural mode of inventing and developing a style of art has been completely reversed, or, rather, put aside, and instead of the natural growth of the Gothic or any other single and simple style of architecture, it has come to pass that out of every phase of Gothic, and out of every phase of the Renaissance, a sort of *compo* architecture has risen up, meaning nothing whatever and expressive of nothing. But by the side of all this, and irrespective of it, there has been going on a style of building, as we must call it, consequent on the needs of the railways in their taking the place of the common high roads, which might, if left to itself, have created a style

of architecture peculiar to the age, and really expressive of its wants and modes of thought. Unfortunately, this has been prevented by the employment by our civil engineers, whenever any architecture has been thought necessary, of the professional architect, or, rather, his assistant, who has been called in to add the architectural features to the mere construction. This most curious state of things is exemplified in the two railway bridges over the Thames at Hungerford and Blackfriars, and the two new bridges at Westminster and Blackfriars. These structures show the constructional work of the civil engineer and the art work of the architect combined, or, rather, simply brought together as if by accident. It is a kind of work and mode of doing it so peculiar to the time, that a few thoughts about it may not be uninteresting nor uninstructive.

But before we can do this it is necessary to remind the reader of the nature of the older and primitive architectures, and to see how very simple they were originally as they grew, in each country, out of the constructional knowledge and requirements of those who used them, and out of the materials at their command. Be it well and constantly borne in mind that any one old style of architecture was simply the growth of the art faculty of the executive artists of the time out of the simple construction, while in these modern days it is the importation, from a foreign source, of the art element, and its amalgamation, foreign though it be, with the building construction; while in engineering, as we have said, it is the mere fixing or gluing on to the constructional forms the architectural and fine art decoration. It is only by accident that the architecture in a railway bridge forms any part of the necessary constructional building. And this it is that leads to the consideration, very shortly, of the different styles of simple architecture, and to a short definition of architecture as a fine art and means of adding the grand idea of beauty to the necessary quality of utility.

We may, then, to make our meaning as clear as possible, define architecture to be the individual expression, in each age and country, of the wants and feelings of men as influenced by the climate, materials, and vegetable and animal life in each country.

And under the general term Architecture we would also include sculpture, when forming, as it always should do, a part, and a ncessary and vital part, of the architecture, and also all decorative art, as wall painting.

The arts of sculpture, painting, and the decorative arts, have in all countries, when not corrupted by foreign influence, followed the architectural arts.

The architecture of the world may be most conveniently and simply divided into two great and leading divisions or orders, viz.: First, the architecture of walls, piers, or columns, covered by a lintel or a flat roof, and by a gable roof; second, the architecture of walls, piers, or columns, covered by arches, either round or pointed, and by a gable roof more or less steep.

The intermediate style of walls, piers, or columns, the round arch and the lintel, forms a style composed of both the others; it arose from the discovery, or invention, or use of the round arch by the introduction of it between the columns of the earlier architectures and their lintel.

Under either one of these three heads we shall find that all the styles of architecture that have at any time appeared in the world may be ranged, or that can ever appear, and that the only real distinction there is or can be between them may be resolved into a difference in the mode of their ornamentation. It will thus be found that what at first seems of a nature the most complicated and difficult is easy of comprehension, thus:

To the Lintel order of architecture belong, in the order of their date, the Egyptian, Assyrian and Persian, Hindoo, Chinese, Greek, Etruscan, in the Old World; and Mexican and Peruvian, in the New World.

The architecture of Ancient Rome was the link which joined together the two great and primitive orders, by the introduction and use of the round arch. It belongs more properly to both divisions, rather than as forming a distinct style. In the architecture of Ancient Rome, the temples, as that of Jupiter Stator, belong to the first, and the aqueducts, triumphal arches, etc., to the second. But the latter, in strictness of division, belong, as I have said, to both also; as in them are for the first time found the three grand constituent elements of all architecture—

the column, the arch, and the lintel. The full development of the Arch architecture is first seen in the Romanesque, when free of the lintel. Its perfection is first seen in the Early Gothic.

To the Arch order of architecture belong, in the order of their date, the Roman; Romanesque, in all its varieties; Arabian, or Moorish, as it is sometimes called; Gothic, in all its phases; and the Renaissance, or, Revived Roman (not Greek) architecture, or Italian, as it is usually called; and the whole of that wide school of styles of which theElizabethan,or Italo-Gothic of England, may be cited as an instance. The whole of the architectural styles, from the fifteenth century till the revival of the Gothic in our own day, is to be classed under the general term of the Renaissance. Mr. Wornham has classed no less than seven distinct varieties.

By carefully observing this simple division, we shall at all times be provided with a key map, so to speak, whereby each one of the architectures may be referred to its proper division, and any collection of architectural examples will be readily understood, and their place known by referring them to the varieties or subdivisions of the leading or primitive styles. A correct and strictly scientific division, it will be evident, is an all-important matter in the arrangement and easy understanding of any collection. It is all-important, too, in the arrangement of a catalogue or explanatory class-book.

Mr. Ruskin has adopted, in his classification of the styles, a somewhat different division from that which I have done, but perhaps hardly so clear and distinct. It seems almost a pity that he is so one-sidedly attached to a special phase of southern Gothic. In this northern climate we seem to be unable to do anything with it. It has failed completely.

Pugin can hardly be said to have attemped any analysis of architectural styles generally. He interested himself in nothing but the Gothic, and that chiefly of his own country. It is very greatly to be regretted that he did not live to more completely work out and perfect his own peculiar phase of Gothic—almost a creation of his own.

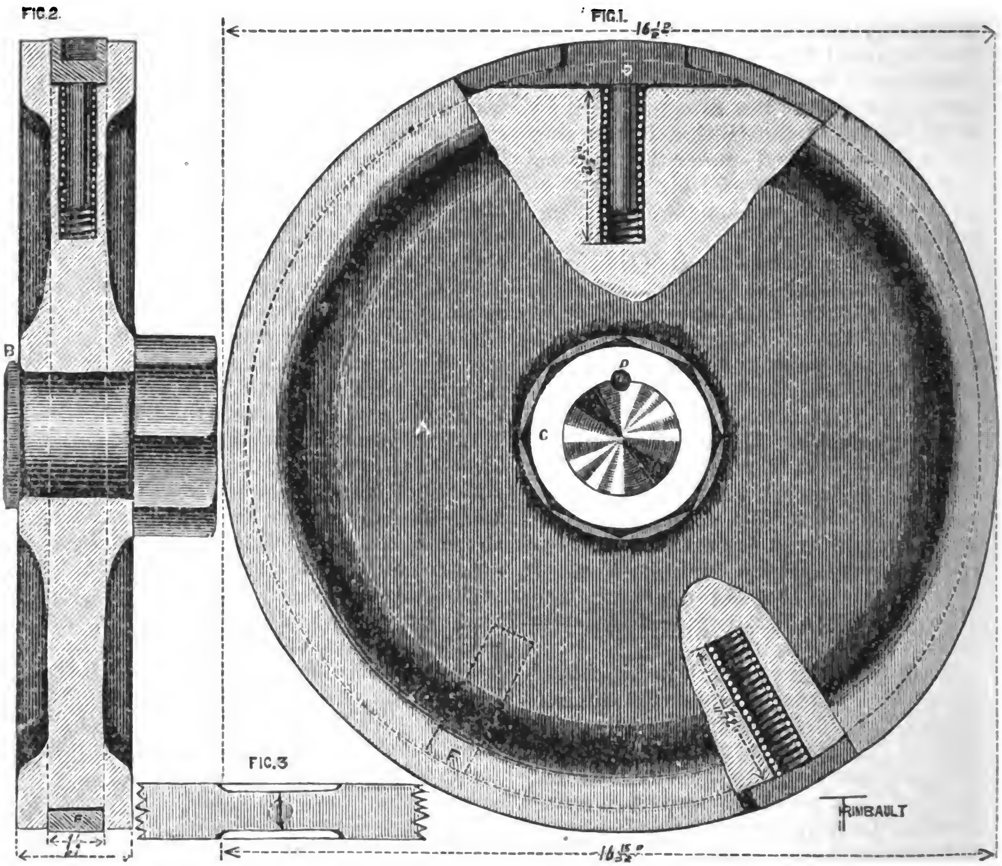
It is absolutely necessary to bear these leading principles in mind, before commenting at any length on the nature and meaning of engineering and the great works of the civil engineer. Of course I refer solely to the building part of engineering and not to mechanical work. As an example of my meaning, the new railway bridge at Hungerford will afford an apt illustration, and will be a guide to the consideration of other works. The bridge consists simply and constructively of that perhaps one solitary invention, as far as building goes, of modern times—the trellis girder, or constructive wrought-iron lintel, stretching from column to column over a wider space than would be possible otherwise. These support the rails and roadway, and are themselves borne up by the circular cast-iron cylinders or columns. These columns have no capitals further than the mere flange for the holding bolts at the top of the cylinders. There is no attempt by the engineer at ornament, or art, or architecture anywhere—it is all purely and solely constructive ; and it is a great pity that, by way of instructive example and guidance, it had not been left so. There was nothing unsightly in it ; it plainly revealed its purpose, and showed us what simple iron construction is like. But, unfortunately, the engineer of it, Mr. Hawkshaw, seems to have called in the assistance of an architect to glue on to it something which in these days goes by the name of architecture, and the consequence has been that this ingenious bridge is disfigured by a series of lumps of stone perfectly useless and unmeaning, and which have but the sole effect of dwarfing the iron-work and hiding its usefulness. These lumps are surmounted by a number of lamps which are never lighted, for the simple reason that they could throw light on nothing but the surrounding air! It is a most instructive example of how to spoil a good opportunity of doing something in the way of engineering architecture.

A GREAT economy in the manufacture of bread, is secured by the following process: Gluten to the amount of 10 or 12 per cent. is extracted by boiling water from bran, and the flour is kneaded with this infusion, whereby from 20 to 30 per cent. more bread is obtained. The bread, of course, is not so white as that of first quality, but is much more nutritious.

LOCOMOTIVE PISTON.

From "The Engineer."

Accounts of novelties, though undoubtedly excellent things in their way, are sometimes of less value to an engineer than descriptions of arrangements or details which have been found by the test of lengthened practical experience to give thoroughly good results; and this being the case, we propose to give from time to time in this journal engravings illustrating the standard locomotive details which have been adopted by some of our chief railway companies. We thus give, herewith, engravings of the standard locomotive piston, designed by Mr. Samuel W. Johnson, the locomotive superintendent of the Great Eastern Railway—a piston,



we may add, which is of very simple construction, and which has been employed by Mr. Johnson for several years past with the most satisfactory results.

Referring to our illustrations, Eig. 1 is a front view, part in section; Fig. 2 is a section through the centre of the piston; Fig. 3 is a plan of the packing ring joint and tongue.

The piston, A, is made of cast-iron, the rim and boss being 2½ in. thick, and the rim or piston head being turned a full $\frac{1}{32}$ in. smaller than the diameter of the cylinder. The boss or centre is bored out conically, the taper being 1 in 23, and is exactly fitted on the piston rod, B, and secured by a brass nut, C. After the piston is fitted accurately on the end of the piston rod and the nut well tightened, a hole for a ½ in. tap pin is drilled in the end, one half in the nut and the other in the end of the piston rod. A wrought-

iron pin, D, is then tightly screwed into this hole, and the end is carefully riveted over. This pin prevents the nut from slacking back.

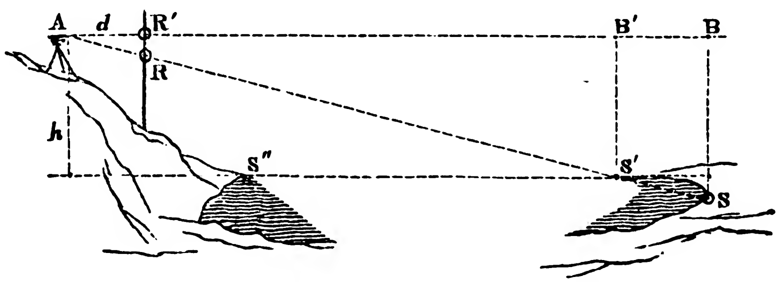
The packing ring, E, is also of cast-iron, $1\frac{1}{4}$ in. wide and $\frac{3}{8}$ in. thick. This ring is turned on the outside and edges only, and is made $\frac{1}{16}$ in. larger in diameter than the cylinder, being subsequently cut, as shown in Fig. 3, and $\frac{1}{4}$ in. taken out of it. It is then sprung into its place, and kept in its position by three spiral springs, F, two of these springs being placed near the bottom of the piston, and so compressed that they will just carry the weight of the piston and balance the thrust of the other spring, which is placed at the top of the piston directly under the brass tongue or stop piece, G, and the joint of the packing ring, so as to keep it bearing on the cylinder. All the springs are alike in strength, but it will be seen that the recess for the top spring is made $\frac{1}{8}$ in. deeper than the other two, so that the spring merely keeps the tongue and ring in contact with the cylinder. The piston, when finished, is found to move easily and fit accurately, and is comparatively light, the total weight, complete, of a $16\frac{1}{4}$ in. piston, including the brass nut, C, being 3 qrs. 14 lbs., and the total cost of the piston, finished complete, with packing ring, springs, tongue, brass nut, and tap pin, does not exceed 25s. The average mileage of one packing ring is from 25,000 to 30,000 miles, and the cost of the rings is but 9d. each.

MEASUREMENT OF DISTANCES BY THE LEVEL.

By W. L. MARCY.

To measure the contour of a lake with a level, ascertain by levelling the height of the level at A, above the water near the point of observation—denote it by h, also the distance AR′ of the level rod by d.

First level the instrument, and call



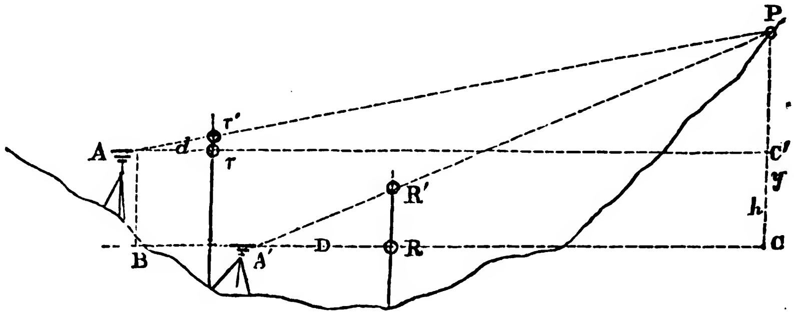
the reading of the rod R′; then depress with screws until the line of sight touches S, and call the reading of the rod R S″, S′ being the apparent level; it is obvious from simple proportion, that $AB' = \frac{hd}{R' - R}$, which answers for all purposes of plotting when the lake is small. Now h and d remaining constant, several points can be determined in a few minutes. To determine A B we can add $\frac{(AB)^2 \times .571}{R' - R}$ R′ A B being expressed in miles. For greater accuracy still, call A B x, which gives the quadratic

$$x = \frac{hd + x^2 .571}{R' - R}.$$

If the observations are made with a transit level they can be plotted by angle or course radiating from the points of observation to the different projections or indentations around the water; or if taken by a level only, the position of the rod may be taken by measurements, so that the whole can be easily plotted.

To measure distances with a level, both horizontal, vertical or inclined:

Let P be the point to be determined. A, A′ P and the rod being in the same plane. This plane can be determined by the eye—for the error is as the versin. of the variation from the plane—since the projections of B A′ or A r′, A′R′, are equal to those distances respectively, multiplied by the cosine of variation, which makes the error very small.



Beginning at A' we take the reading R, then elevate the line of sight to P, taking the reading R'. Level back to A, proceeding as before. Denote A'R by D ; Ar, d ; A B, h c'c ; BA, h ; A'C by x and PC by y.

We may obtain by proportion the following equations for x and y :

$$y = \frac{R' - R}{D} \times x, \text{ and } y - h = \frac{r' - r}{d} \times (x + b),$$

which give $x = \frac{D\,b\,(r'-r) + h\,D\,d}{(R'-R)\,d - (r'-r)\,D}$, from which we we can readily find the vertical and inclined distances.

In running preliminary lines it is often desirable to find where your grade will strike on a distant hill, also what the grade is to a point required to be made in the survey. First, measure from the level toward the point to which you are running a given distance D, and take the level reading; then elevate the target D x grade, and the line of sight raised to the target will cut the hill above or below grade to the amount that the instrument is above or below the same. Denote the level reading by R, the upper or lower reading by R' ; then $\frac{R'-R}{D}$ will be the grade to any point. When the lines deviate too much from an air line, the variation from these results in running will always be in excess both in ascending and descending, in consequence of lengthening the line. When the surface curves regularly, the increase in distance will be nearly as the versine of the deflection from the air line to the extreme points in the surface, right or left.

London Pavements.—"A Merciful Man," who signs "E. F. J.," writing from Paris to the "Times" of the 8th inst., extolled the excellence of the roads in Paris, and held them up as a model for London authorities. "It is perfectly true," says the Paris Correspondent of the "Times," "that the macadamization here is excellent, that the carriage ways where that system is adopted present a compact, well-bound surface, upon which the mud rarely becomes deep, and which is easily cleaned by the roller brush here in use. With respect to the other method of laying bitumen over lime and sand, it looks well and has advantages for pedestrians, but the horses and those who drive them do bitterly complain of and anathematize it. The sand sprinkling referred to by 'E. F. J.' is partial and ineffectual, and it is painful to see the horses struggling for foothold on the smooth surface, which, in certain states of the atmosphere, becomes greasy and almost as slippery as ice. So many are the complaints I hear of it that I am surprised still to see it being here and there laid down. It is all very well, however, to recommend London to improve its ways after the Paris model, but is London disposed to pay for such improvements? An army of men is here daily employed in taking care of the streets, roads, parks, and gardens of Paris, scraping, sweeping, rolling, watering, brushing up the mud with the roller above mentioned, strewing sand, and in other ways attending to the toilet of this luxurious city. Fancy stationing detachments of men with baskets of sand to diminish the slipperiness of the road!" Such a thing is a fact and not a fancy in one part of London, at least so we are informed by a correspondent. A sweep and a basket of sand are to be seen daily in that part of Threadneedle street recently paved with asphalte.

Some Northern capitalists have invested $1,500,000 in land along the Chesapeake and Ohio Railroad, Va., and purpose to build three or more large iron furnaces, one of which will be at Clifton Forge.

THE HEATON STEEL PROCESS.

MONSIEUR GRUNER'S REPORT.

(*Continued from page* 138.)

But the nitric acid is not the only thing reduced in the converter; a part of the soda is transformed into sodium at the moment when the alkali passes in thin streams through the bath of pig. The sulphuret of sodium and the sodium itself, which we find combined with the iron in refined metal, leave no manner of doubt on this point. But we have other proofs of it to advance. The jets of yellow flame which escape from the refined metal must be sodium vapors. The black smoke which issues from the converter when the flames go out must be chiefly sodium. I say chiefly, because the black smoke was not abundant in the case of the Longwy conversions, in which we proved that the soda partially disappears on account of the small quantity of silica in the slag. The black smoke of the Heaton converter is condensed vapor. It is a metallic dust just as ordinary smoke is carbon dust, and just as steam is a dust of liquid water. The smoke of the converter is necessarily complex. We ought to find in it volatile phosphoric compounds mixed with the sodium, and probably also, as in the Bessemer process, particles of iron and manganese. But this much is certain, that sodium is its chief constituent whenever the soda is not saturated with silica. This is precisely the distinction between the Longwy and the Hayanges conversions. In the latter case there was but little black smoke. The red vapors predominated, and calculation has shown us that in this case almost the whole of the soda was retained by the silica, while in treating less silicious brands a great deal of it disappears.

Let us remember, too, that, as in the Bessemer process, the heat developed during the reaction depends especially on the proportion of silicon contained in the pig. The charges of nitrate were the same in the first and fifth conversions—if anything the largest in the first. Well, the temperature was far higher in the fifth. The refined metal which was produced in this experiment was still semi-fluid at the end of an hour, while the product of the Longwy pig was solidified in less than a quarter of an hour. Now, the only difference between the two brands is, that one contains 3 per cent., and the other only 0.9 per cent. of silicon.

When lime is mixed with the nitrate, this also, like the soda, is partially reduced by the molten metal. This is proved by the experiment reported on by Dr. Miller, 14th October, 1868.

The products which he analyzed came from the conversion of a mixture in equal proportions of Clay-lane and Stanton No. 4 brands, both made from the oolitic ores of the upper lias.

The charge of molten metal was the same as in the preceding conversions, but the nitrate chamber was charged with 169 lbs. of nitrate, 40 lbs. of silicious sand, and 20 lbs. of air-slaked lime. The resulting slags were pasty, and unusually difficult to separate from the refined metal.

Dr. Miller's analysis gave the following results:

	Remelted Pig.	Refined Metal.
Carbon	0.02830	0.01800
Silicon	0.02950	0.00266
Phosphorus	0.01455	0.00298
Sulphur	0.00133	0.00018
Arsenic	0.00041	0.00039
Manganese	0.00318	0.00090
Calcium	0.00318	0.00319
Sodium	0.00318	0.00144

The refined metal consequently contains both sodium and calcium, only we must not forget that in the refined metal we always find a little slag, and that part of the calcium and sodium here ought to appear as silicates of lime and soda.

Dr. Miller did not analyze the cast-steel made from the cakes, but the samples were subjected to the tension test at Mr. Kirkaldy's, as the Moselle samples were.

Mr. Mallet gives, as the mean results of the testings which took place in August and September, 1868, the following figures: breaking strain per square inch of the original section, 41.73 tons, with an elongation of 7.20 per cent. Later experiments on steels made from various English brands gave the following results:

Description of Steel.	Breaking Strain.		Elongation per cent. of original length.
	Tons per square inch.	Kilos. per square millimetre	
Cast Steel:			
Dowlas No. 3, with 10 per cent. of nitrate.	42.2	66.00	1.4
Middlesbro', No. 4...	47.1	74.00	6.3
Glengarnock, No. 2..	41.1	65.00	6.3
Wokington hematite, with 7½ per cent. nitrate	48.4	76.00	2.7

We see, by comparing these figures with the table of the Swedish and Newberg steels, that the elongation is small as compared with the breaking strain, and that consequently all these steels, like those of the Moselle, are deficient in elasticity. We have still to examine from a chemical point of view the merchantable products of the refined metal, viz., malleable iron and steel. The malleable iron, as I have already said, is of little interest from a practical point of view, because the Heaton process is too costly for such a product. I have therefore contented myself with analyzing two samples.

Rolled Iron.—I analyzed the two bars, No. 1 and No. 2 of the first conversion, by the same process as the cakes, and operating on 10 grammes. Here are the results:

Elements.	Flat bar (Longwy No. 1) obtained without piling from conversion No. 1.		Flat bar (Longwy No. 1) piled from conversion No. 1.
Silicon.....	0.0023	.. ..	0.0021
Phosphorus	0.0022	.. ..	0.0016
Sulphur....	0.0002	.. ..	0.0002 at outside.
Carbon.....	0.0006	.. ..	9.0008

Comparing these figures with the analysis of the cakes of the first conversion, we see that the purification has progressed in every item but that of silicon. The phosphorus has been reduced from 0.0064 to 0.0022 and 0.0016, the sulphur from 0.0009 to 0.0002, the carbon from 0.012 to 0.0006 and 0.0008. The silicon, on the contrary, seems to have increased. But on this head we must observe that at least half the amount which figures here as silicon is due to the slag intermingled with the iron, so that in reality the fining has been progressive even here. Nevertheless, the iron is still impure; and moreover, as has been already said, it has been burnt by the workmen. It contains too little carbon with too much phosphorus, and this accounts for its small elongation before fracture. The piling, too, has produced very little effect either in point of chemical purity or elasticity. Dr. Miller analyzed the malleable iron prepared from the Claylane and Stanton brands, with the following results:—Sulphur traces: carbon, 0.00993; silicon, 0.00149; phosphorus, 0.00292. Sulphur traces: arsenic, 0.00024; manganese, 0.00088; calcium, 0.00318. Sodium traces.

The iron is not burnt; it seems, however carbonized; but for that very reason the purification is less than with the Longwy iron; the phosphorus has but little diminished.

Ingots of Steel.—In the analysis of the steel ingots I followed the same method as with the pigs, the irons, and the cakes, so as to obtain comparative results:

Elements looked for.	Ingot of Conversion No. 2.	Ingot of Conversion No. 3.	Ingot of Conversion No. 6.	Ingot of Conversion No. 8.
Silicon.....	0.0014	0.0018	0.0021	0.0017
Phosphorus	0.0038	0.0025	0.0034	0.0050
Sulphur....	0.0003	0.0005	Trace.	0.0002
Carbon.....	0.0036	0.0055	0.0035	0.0062

Comparing the figures with the analysis of the cakes, we see at once that the purification has progressed, either by the atmosphere more or less, oxidizing of the crucibles, or by the addition of malleable iron and spiegeleisen. The percentage of phosphorus especially has diminished, though unequally. In the ingot of conversion No. 2, it has diminished from 0.0059 to 0.0038, while the silicon has remained stationary. In the ingot of conversion No. 6, the phosphorus is 0.0034 instead of 0.0078, and the silicon 0.0021 instead of 0.0045. This difference is greater on account of the dose of malleable iron having been increased in this instance. 14 lbs. of iron was used with 34 lbs. of cake, instead of 12 lbs. with 33 lbs. in the second operation. But this difference in the charge is not sufficient to account entirely for the diminution of phosphorus in No. 6. The evident anomaly is no doubt due to the want of homogeneity in the cakes. The anomaly is still greater in the case of the steels Nos. 2

and 3. The cakes of conversion No. 3 were obtained with less nitrate than those of No. 2, and yet we find in ingot No. 3 less phosphorus than in No. 2; on the other hand it contains, as we should expect, more silicon and carbon. At any rate we may deduce from these analyses that the ingots resulting from the white pigs, just as we proved in the case of the cakes, are better refined than those from the gray pigs. And this general result of the analysis is in accordance with the breaking strains, considered both with reference to the area of fracture and with reference to their elongation before fracture. When we compare, by the table of the breaking strains the steel of similar degrees of carburization resulting from different brands, we find that the steel of conversion No. 2, which is but little carburized, only elongates 12.5 per cent, while the bars of conversion No. 6, which, however, are double their dimensions, hardly elongate 1.3 per cent. And so the steel of conversion No. 8 elongates less than that of No. 3. To sum up, we see that the steel ingots prepared under the above conditions contain 0.0025 to 0.0038 of phosphorus and 0.0014 to 0.00018 of silicon when the Longwy white brands are converted, and 0.0034 to 0.0050 of phosphorus with 0.0017 to 0.0071 of silicon when the Hayanges gray pigs are treated.

We may add, too, that the purity of the tilted steel bars would be about the same; for simple reheating at a low red heat, followed by a rapid hammering, could hardly effect any perceptible change in this respect. The following table of their percentages of carbon, determined by the Eggertz method, suffices to prove it :—

	Carbon in the ingots.	Carbon in the tilted bars.
Steel of Conversion No. 2	0.0036	0.0033
" " No. 3	0.0053	0.0054
" " No. 5	0 0035	0.0032
" " No. 8	0.0062	0.0048

Hence it follows, definitively, as was also proved at Königshutte, that 0.003 to 0.005 of phosphorus does not prevent cast-steel or homogeneous iron from working well hot; but the metal, though its resistance under slow tension is often as high as that of good steel, really wants body. It is harsh, and has not the dynamic resistance of good steel.

Must we, then, conclude that the Heaton process is worthless, and that its adoption would offer no advantages? Such is not my conclusion. Doubtless we must not expect to obtain by this process first-class steel. Let us leave this specialty to the non-phosphoric ores, such as the spathic and the magnetic protoxides; but, on the other hand, let us not use these rare and expensive ores for rails. If we do so, what is to become of the common iron ores?

The nitrate process eliminates the phosphorus, at any rate partially, and better still, the silicon and the sulphur. The degree of purification depends on the proportion of nitrate. It is a question of cost. The question is, whether, in refining by this process white forge pigs produced from the common ores, we can obtain a metal of sufficient tenacity for rails and plate iron at a price less than the present price of Bessemer rails. The experiments cited do not enable us to give a categorical answer to the first question, viz., as to the working strength of the bars. Concussion tests should be taken instead of tension tests; or, better still, bending tests pushed to their elastic limits, similar to the tests reported in my work on steel. We should ascertain what percentage of phosphorus and silicon may be present without impairing the strength of the rail. Such experiments seem to me of importance, and I hope shortly to be able to enter upon them.

In the second place, it is necessary to show that the use of nitrate will not involve too great a cost. But first of all I must say how I understand the practical working of the Heaton process. The refined metal is not "steel," and still less "homogeneous iron." It is simply "purified pig," which ought to undergo a new treatment similar to the refining process of the Siemens-Martin furnace. Consequently it is to the pure brand, treated in the Martin furnace, that we should compare the Heaton refined metal. But we have seen that to refine pig iron by the new process we should have to go as far as charges of 10 to 15 per cent. of nitrate. That would be, at the present price of nitrate, a cost which would, for nitrate alone, reach 32s. to 48s. per ton of refined metal, and in any case 20s. to 30s. if we assume that the price of nitrate will come down from £16 to £12 per ton, which seems quite possible by better organization of the mining industry, and of the

means of transport from the mines to the coast of the Pacific; and here we should note, that the feasibility of the practical adoption of the Heaton process depends to a great extent on the price of nitrate. This price was about £12 per ton before the Peruvian earthquake of last year. It was raised to £16 in consequence of that disaster. The deposits of nitrate in Peru and the north of Chili are very extensive, and to a great extent still undeveloped. An increased consumption, instead of raising the price, would probably lower it by causing the working of new mines and the construction of cheap railroads from the nitrate district to the coast. However, even at a price of £10 or £12 per ton, the cost would still be high if the phosphorus and silicon were to be oxidized exclusively by nitrate. But we can do better than this.

I have already said that the common refining and puddling process easily eliminate the greater portion of the silicon and phosphorus in the presence of the basic slags. Between these two methods, moreover, we need not hesitate. The finery process is preferable in point of cost, and it can be carried out either on the "low hearth," or in the reverberatory furnace, only in either case we must have furnaces with chilled metal lining and strongly basic slags. We may then have recourse to the English finery and use coke as pure as possible, and render the slags extra basic by repeated additions of rich and purer ores of iron and manganese. Or, if we fear contact with sulphurous and reducing fuel, we can use a reverberatory furnace with an air-current or blast heated by coal or gas on the Siemens or any other plan.* But in any event the *sine qua non* of success is to have the furnace lining of properly chilled cast-iron like the boiling puddling furnaces, and to fettle the interior with roasted scrap or rich oxide of iron. We have already seen, by the example of M. Eck's furnace at Königshutte, what is the result of refining on a sand hearth. The phosphorus becomes concentrated in the refined metal, because the slags become silicious. This is equally the case with the Martin furnace, the heart of which is sand. The phosphorus cannot be removed on account of the silicious character of the slags, and we cannot in this case render them basic without destroying the furnace. The sand and the bricks are quickly melted down by the oxide of iron. But what cannot be done in an ordinary reverberatory furnace succeeds perfectly in a furnace lined with chilled cast-iron, arranged like *a boiling furnace.* The pig would be there melted—or, rather, it would be run in from the blast furnaces in a molten state. It would then be refined between a hearth of oxide of iron and a layer of ferruginous slags, maintained in a basic condition by repeated additions of rich ore, and, if need be, as in the Eck furnace, by the aid of plunging tuyeres and a blast. The operation would be stopped short of decarburization; then, to finish the purification, the refined metal would be run direct into the Heaton converter, where a small charge of nitrate would easily eliminate almost the whole of the silicon and the remaining phosphorus and sulphur. Thence the refined metal would pass into the Martin furnace, where its conversion into steel or homogeneous iron by reaction would be finally completed.

I cannot refrain from taking this opportunity of observing that the common Martin process should be modified in the same way. What is the fault of the Martin process? It is its extreme slowness if the pigs are at all silicious. It produces steel by *reaction*—that is to say, by simply mixing malleable iron and pig iron, but if the pig contains silicon how is it to be got rid of except by oxidation? and how oxidize it without destroying the lining of the furnace by the added oxides? When the pigs are silicious, the plan adopted is that of prolonged fusion to oxidize the silicon by the action of air. Instead of heating the pig in an ordinary reverberatory furnace and then remelting it in the Martin furnace, it would certainly be better to refine it first of all in a *boiling* furnace (*four bouillant*) and thence to run it direct into the Martin furnace to be mixed with the malleable iron.

But let us return to the Heaton process for the treatment of the common brands. These are the modifications the adoption of which, in my opinion, would permit its practical application to the production of rail metal from such brands.

(1.) The molten metal should be run direct from the blast furnace into the

*Mr. Samuelson's new furnace, with a pivoting hearth, above mentioned, would answer the purpose.

finery furnace, as is done in several Welsh works, or, better still, into a *boiling* furnace to be refined by blast and oxide of iron.

(2.) Thence the refined metal should be run into the Heaton converter to be treated with nitrate. (We know that in some works in Wales the refined metal is run direct, to be refined with charcoal, into a low Comtois hearth.)

(3.) Then the metal, twice refined, should be passed at once, whether fluid or solidified, into the Martin-Siemens furnace, to be converted into soft cast-steel or homogeneous iron by being mixed with malleable iron or spiegeleisen. Let us add that if we carried the refinery in the converter as far as true decarburization, the refined metal could be charged into the Martin furnace instead of malleable iron. That depends on the degree of purification attained. We see that by this mode of treatment we should adopt that valuable principle of progressive refining which I long ago recommended in my work on steel (p. 106) for the treatment of the common brands.

It is unnecessary to add that if the pig only contained one per cent. of silicon and one-quarter to one-third per cent. of phosphorus, we might dispense with the first finery and run the metal direct from the blast furnace into the Heaton converter. We have still to prove that the cost of this double finery would not be disproportionate to the value of the product we should expect to obtain.

The average waste of the finery is from 8 per cent. to 10 per cent.; but this waste would be reduced if we added rich ore to the molten metal. I will assume it to be reduced to 5 per cent. On the other hand, the average consumption of coke in England is from 200 to 250 kilos., say 440 lbs. to 550 lbs., per ton of refined metal, when the molten metal comes direct from the blast furnace, and would be 400 kilos., say about 8 cwt., of coal if we were to work in the same way in the reverberatory furnace. The cost of manual labor and incidental charges vary, as we know, from 2s. 6d. to 3s. 4d. per ton. Taking, then, the actual price of the Moselle forge pigs, we should have for every ton of refined metal: 1 ton of forge pig at 63f. (£2 10s.), 5 cwt. of coke at 7½f. (6s.), labor and incidental expenses 4f. (3s. 4d.). Total, 74f. 50c. (£2 19s. 4d.). In the reverberatory furnace we should have 400 kilos. (say 8 cwt.) of coal at 12f. or 10s., say 4f. 80c. instead of 7f. 50c., or 4s. instead of 6s., which would reduce the price of the refined metal to about 72f., say £2 17s. 4d. This is the cost we will assume, because refining in the reverberatory furnace is always more effectual than fining on the hearth. The pig so refined would waste but very little in the converter, because the silicon and phosphorus would be to a great extent eliminated. We may take 5 per cent. as a maximum. If, on the other hand, we assume that we have to oxidize 0.003 to 0.004 of silicon, and as much phosphorus and sulphur, and about 1 per cent. of carbon, we should need 20 kilos. to 22 kilos., say 44 lbs. to 48 lbs., of oxygen, which would take 1 cwt. of nitrate. The cost would then be: For 1 ton of refined metal at 75f. 60c. (£3 9s.); 1 cwt, of nitrate at 400f. or £16 per ton, 20 f. (16s.); labor and wear and tear, etc., 4f. (3s. 4d.). Total, 99f. 60c. (£3 19s. 4d.). With the expenses of management and royalties we should so arrive at a maximum cost of 110f. per 1,000 kilos.—a figure which would be reduced to 100f., or £4, if the price of nitrate were to be reduced, as is probable, or if cheaper chemicals were to be partially substituted for the nitrate. Now, we know that the average price in France of brands suitable for the Bessemer and Martin processes is 115f. to 120f. There would, therefore, be a certain amount of profit in using nitrate (even at £16 per ton) for the purification of common brands. It remains to be proved by new experiments if rails so made would possess, as I believe they would, sufficient elasticity.* (*Resistance vive.*)

I have just said that the cost of the refined metal might be lowered if we were to substitute cheaper chemicals for some portion of the nitrate. Let us go into some details on this question.

In the first place, we might, to some extent, substitute carbonate of soda for the nitrate. This salt has an oxidizing effect by its carbonic acid, which is reduced to carbonic oxide. Its available oxygen is 15 per cent., instead of 44 per cent.; but the proportion of base which would take up the acid is 58 per

* The experiments on the "dynamic resistance" of Heaton steel, published by Sir Wm. Fairbairn after Mr. Gruner's work was in type, appear to establish this point conclusively in its favor.

cent. instead of 34 per cent. From this point of view there would be something to be gained by mixing these two salts. The experiment was tried on my suggestion at La Villette. Instead of 10 per cent. of nitrate, 9, 8, and 7 per cent. were used successively with 1, 2, and 3 per cent. of carbonate. The phenomena of conversion were the same, but the reactions were less violent, and the metal also seemed less modified. The analysis of the products is not yet finished. I cannot, therefore, be positive as to the results.

Again, to augment the percentage of oxygen while reducing the cost, I caused peroxide of manganese to be mixed with simple nitrate, and with nitrate and carbonate. This oxidizing reagent had also been tried by Mr. Heaton at Langley Mill. It was given up because the temperature developed is not always high enough to melt the protoxide, in which case the product is a pasty mass and the slag not homogeneous. The oxygen liberated is, in fact, 18 per cent. at best; sometimes only 12 or 15 per cent. In spite of that the conversion is quite as successful when we content ourselves by substituting an equal weight of peroxide for about one-third or one-fourth of the charge of nitrate. But we must take care that the mineral be pounded fine, and thoroughly mixed with the nitrate, or carbonate and nitrate.

Mr. Heaton at first used a mixture of nitrate and slaked lime. This was done in July, 1868, when Dr. Miller and Mr. Mallet went to Langley Mill to investigate the new process. The lime acts as a strong base, but renders the slag more pasty. That is a disadvantage. If we wish to arrive at running the metal direct into a Siemens furnace we must have fluid silicates, so that the metal may disengage itself from the slag. This end is attained by substituting fluor spar for lime, as Mr. Heaton has himself lately proved at Langley Mill. My only fear is that some little sulphur might be introduced into the metal with the fluor spar, which almost always contains sulphate of barytes.

We can render the slags perfectly fluid without running the same risk by mixing common sea salt with the nitrate. The experiments I have just had tried at La Villette prove the efficiency of chloride of sodium. With mixtures of 7 per cent. of nitrate and 1 to 2 per cent. of sea salt, the slags become as liquid as water. The phenomena of conversion are just the same as usual, except that there is an abundant liberation of suffocating vapors. The sea salt is volatilized with other chlorides; but these chlorides probably themselves effect some purification of the refined metal. That is a matter still under examination. In any case, 1 to 2 per cent. of sea salt will always be very useful to increase the fluidity of the slags of the converter.

In fine, we see that there are still questions for examination, and that it may be advantageous to add other reagents either as fluxes or oxidizers to the nitrate.

I have but one other point to speak of, viz., the arrangement of the apparatus. The converter is very simple. The molten metal can be easily run into it, either by a trough, or by a crane ladle, or by a wagon running on trams. The most troublesome part of it—at any rate, when converting on a large scale—is the manual labor, and the fixing of the nitrate chamber. But a little tramway passing under the converter would allow of its being run into its place, and, instead of attaching the chamber to the converter by clamps, one might use a hydraulic lift, which would hold it tightly in its place during the conversion. After the conversion the nitrate chamber, with its contents of refined metal, would be removed in the same way to the Siemens furnace, where the treatment for steel would be finished.

Having now arrived at the end of my long memoir, I think I should sum up the principal results.

Conclusions:—The Heaton process could never, *from any point of view*, be a substitute for the Bessemer and Martin processes. These produce ingots of steel or homogeneous iron from pure brands. The Heaton process deals with impure brands, and seeks to convert them into a refined metal more or less purified, the treatment of which has to be finished in a Siemens furnace. Its aim is to preserve for the common ores the place which the pure ores have for some time tended to usurp—iron and steel for springs, tires, and large guns.

Plates should be left to the pure ores; rails and bars of homogeneous iron,

more or less hard, to the common ores.

The purification is based on the reaction of Peruvian nitrate of soda. The apparatus is simple, ingenious, and very cheap. The operation is rapid, easy to manage, and not liable to explosions.

The nitrate refinery acts like the ordinary methods based on the employment of air or the metallic oxides. The silicon and manganese are first oxidized, the phosphorus and sulphur are eliminated next, the carbon last.

The degree of purification depends, of course, on the proportion of nitrate; but we should hardly be able to achieve an absolute purification even with 12 to 15 per cent. of nitrate.

To reduce the cost we must use brands which contain little silicon, and generally use refined pig rather than crude pig.

The greater part of the silicon and phosphorus ought to be eliminated by a preliminary refining. This ought to be done on the low hearth, or, better still, in a reverberatory furnace; in any case, in a furnace with a lining of properly chilled cast-iron, and with the aid of roasted scrap (*riblons*) or natural oxides of iron, so as to leave the molten metal always exposed to the action of strongly basic slags. Even the pure silicious brands which are meant to be made into cast-steel by the Siemens-Martin process ought to be treated to a preliminary refining.

The Moselle brands were converted at Langley Mill without any such preliminary refining, and with an insufficient dose of nitrate. The result was a refined metal retaining still, in the most favorable case, as much as 0.005 of phosphorus, 0.0014 of silicon, and 0.012 of carbon. This metal was converted partly into malleable iron by a quick puddling, partly into cast-steel by reaction in crucibles. Neither of these methods is economical. The only advantageous method is the conversion of the metal in a Siemens furnace into homogeneons iron or soft steel by the Martin process.

The cast-steel made in the crucible from the insufficiently refined Moselle crude steel still retains 0.002 to 0.004 of phosphorus, 0.0014 to 0.0018 of silicon, 0.003 to 0.004 of carbon, and traces of sulphur. In spite of this the steel works well hot, and gives good results when tested by slow tension; but its elongation is small, and this would seem to indicate a want of elasticity. (*Resistance vive*).

If the process were modified as I have suggested, the results would probably be different. At any rate, further experiments are requisite before we can definitively pronounce upon the elasticity* of the bars prepared by this process; and, on the other hand, it is certain that the Heaton process, properly carried out, would seem to realize the purification of common brands better than any other known method. We are not, however, as yet in a position to affirm that the purification is as complete as we could wish.

* Sir William Fairbairn's experiments.

SAFETY EXPLOSIVE COMPOUND.—Mr. Percy A. Blake, of Aberdeen Park, Highbury, has patented an explosive compound, the constituents of which are simply sulphur and chlorate of potash, in the proportions of about one of sulphur to two of chlorate of potash. These substances can be kept separately in a dry powdered state, and mixed by sifting, when required. This mixture has been known for years to detonate when struck with a hammer, but was useless as an explosive agent, because it merely burnt slowly when fired by the ordinary fuses. The invention, therefore, consists in rendering this compound practically to explode by the use of a peculiar kind of detonating tube or percussion cap, which renders it exceedingly serviceable for torpedoes, blasting, shells, blowing down palisades, and other similar appliances. The detonating tube to be employed is made of metal, about an inch in length, and about $\frac{7}{32}$ of an inch in diameter, the bore being about $\frac{2}{32}$; but the inventor does not confine himself exactly to these dimensions, as a larger or smaller tube can be used for the purpose. First is introduced into it some of the compound, and well pressed down; next, some fulminating mercury, and then a small quantity of detonating silver, and the rest of the tube may be filled up with meal powder. The end of the tube, which is filled with the compound, is to be placed in contact with the compound contained in the vessel to be fired, and the other end may be fired by any kind of ignition apparatus.

LONG AND SHORT PILLARS.

From "The Building News."

It is always a difficult task to define a limit, and to draw the exact line of demarcation between the application of one law and that of another. Occasionally instances occur where one or other of two laws apply with equal fidelity, but these are rare. The subject of our article furnishes a remarkable instance of the ambiguity attending certain descriptions of design. Although we have the elaborate and accurate series of experiments conducted by the late Mr. Hodgkinson to guide us, as well as the rules and formulæ deduced by him to form the basis of our calculations, nevertheless, it is by no means certain what constitutes a long, and what a short, pillar. When extreme cases are taken, there is no difficulty, but it is when the proportion of the length of the column to its diameter is such as to bring it near the boundary that marks the distinction, that uncertainty prevails. Assuming that a long pillar is one in which the ratio of length to diameter, or to the least lateral dimension, is not less than 30, it is evident that a column in which that proportion was 28 or 29 would very nearly be a long column, and must, therefore, present some different features to one in which the ratio is represented by 10 or 12. At the same time there must be some line between the two descriptions of columns, as a pillar obviously cannot belong to both classes. In the category of long and short pillars, the minimum ratio of height to diameter is as 5.5 to 1. When this ratio is still further reduced, so that the proportions become reversed, the specimen is no longer, strictly speaking, a pillar, but a disc. Any of the current coins of the realm are examples of our meaning. Discs will bear an enormous pressure before they become what is technically termed "upset." The crushing or splintering strain, even in the same material, does not appear to be governed by any accurately defined laws. The probability is that the particles of the disc situated nearer to the centre, or axis, are prevented from moving by the confining resistance of those nearer the circumference. It is not difficult to imagine this resistance to pressure in some specimens augmented in this manner almost *ad infinitum*. The compressive strength of a disc being thus so greatly in excess of any requirement that might be demanded of it, any calculation respecting its resistance may be fairly considered superfluous. We confess we should have thought so, but the experience so dearly bought by the Holborn Viaduct proves the contrary. The marble bases, that now, cracked and seamed, bear testimony to the manner in which the public money is squandered through recklessness and incompetency, are not pillars but discs, insomuch as their diameter considerably exceeds their height. Taking $2\frac{1}{2}$ tons, in round numbers, for the crushing strength of marble per square inch of superficial area, it is not easy to understand the splintering of the specimens in question.

From discs we pass to very short pillars in which the length does not exceed 5 or, at the maximum, 6 times the diameter. It was from examples of this kind that the crushing strength of iron and other materials was determined, and their resistance is proportional to their sectional area. Consequently if D be the diameter of one of these pillars and C the crushing strain of the material, then, putting the breaking weight equal to W, its value is given by the equation W

$$W = \frac{\pi \times D^2}{4 \times C}.$$

As an example, let us take the crushing strain of cast-iron to be equal to 40 tons, and the pillar to be solid, and having a diameter of 9 ins. What is its crushing weight in tons? Substituting these values in the equation, we have

$$W = \frac{\pi \times 9 \times 9}{4 \times 40} = 63.6 \times 40 = 2544 \text{ tons.}$$

Allowing one-sixth of this as the safe working load, the pillar may be loaded with 427 tons. The subject of the ratio between the breaking and safe working load, will be referred to in another portion of our article.

There are two other descriptions of pillars requiring consideration, namely, those where the length exceeds 30 times the diameter, and those where the proportion is under that number. The

former of these are known as long pillars, and their strength has been determined by actual experiments, from which rules have been deduced for calculation. As long columns are never cast solid, our investigation may be limited to a consideration of hollow ones. If D and D_1 be respectively the external and internal diameter of a hollow cast-iron column, L the length, and C a constant, the breaking weight W will be represented by the formula

$$W = \frac{C \times (D^{3.5} - D_1^{\ 3.5})}{L^{1.63}}.$$

A little reflection will at once point out that this formula consists of two parts, the theoretical and the experimental or empirical. It was long since demonstrated by Euler, who in his time was the ablest mathematical analyst in all Europe, that the strength of long pillars was in direct proportion to the fourth power of the diameter, and inversely as the second power or square of the length—that is, as $\frac{D^4}{L^2}$. Had the material been wholly incompressible, and the conditions assumed in Euler's theory reducible to practice, the experiments undertaken might have corroborated his statement. But as theory never can be absolutely carried out in practice, the results, to some extent, do not agree. Instead of D^4 they gave a fractional index equal to 3.5. The determination of the constant multiplier C was arrived at by making experiments upon 13 different descriptions of irons, and the mean value was 42.34. A value was also determined for the power of L, which differed from that laid down by Euler. It should be mentioned here that some of the theories of Euler must be received with caution. Euler was, in his day, the most able and distinguished mathematical analyst in all Europe, but he sometimes wrenched data and premises to suit his purpose. Speaking technically, he did not care much about the solidity and stability of his foundation, provided only he was able to erect an elegant and beautiful superstructure. Many of his conclusions redound more to his credit as a subtle algebraist and analyst than to his honor and integrity as a votary of science. Some few of his theories have been altogether exploded by the results of subsequent experiments.

Combining the information derived both from theory and experiment, and substituting for C the value given above, the breaking weight W of a long hollow cast-iron pillar will be given by the equation

$$W = \frac{42.34\,(D^{3.5} - D_1^{\ 3.5})}{L^{1.63}}.$$

The powers of D, D_1 and L may either be obtained from tables compiled for the purpose, or calculated in the usual manner by logarithms. There will be no difficulty in our young professional and amateur readers accomplishing the calculation, if they keep before them the general axiom that the logarithm of $a\ n$ is always equal n times logarithm of a. Or, supposing a to represent any number, and n any index or power, then log. $a\ n$ $= n$ log. a. This is the fundamental equation for all logarithmic calculations, and should be committed to memory by the student. Manifestly there is yet the third class of columns to be investigated, which occupy an intermediate position between the very short and the long columns. They may with propriety be called medium pillars, and their strength will evidently be greater than that of long pillars, and less than that of those which are so short as not to deflect before fracture. These pillars break by the combined action of crushing and bending, and it is impossible to state the exact proportions in which these two agents act in determining the final breaking of a column. But although their exact relative influences cannot strictly be arrived at, yet an approximation sufficient for all practical purposes may be obtained. Thus it is supposed that the pillar has two duties to perform—one to support the weight, and the other to resist the bending action, and that half its strength is employed against the former of these forces, and the other half against the latter. If we put W to equal the breaking weight of one of these medium pillars and employing the same notation as that used previously, we have

$$W^1 = \frac{4\,W\,C}{4\,W\ 3C}$$

In this equation W is the breaking weight of the pillar calculated by the former formula on the supposition that it was a long pillar, and would yield by flexure. Respecting the working load that may safely be put upon cast-iron columns, nearly the same diversity of

opinion exists as in the analogous case of girders and bridges. The nature of the load must always be taken into account, as it exerts quite as much, and perhaps a greater, influence upon the column than its absolute weight. If the column be in a situation where it is certain to be free from vibration, under all possible circumstances, it may be safely loaded with a fifth of its breaking load. Cast-iron pillars are now very much employed in supporting the floors of factories and warehouses, where a good deal of loading and unloading of goods and heavy merchandise is continually going on. In these situations the safe proportion should not be greater than one-sixth. The most trying position for cast-iron columns is where they form portions of cranes and gantries, and are subjected to violent jerks and shakes. Under these severe and exceptional circumstances, the working load should not exceed one-tenth of the actual breaking weight. It may be noticed in conclusion, that short pillars may be loaded proportionally heavier than long ones, since the smaller the casting the better the chance of obtaining them sound and trustworthy. The recent accident at King's College shows the danger of employing unsound and defective castings, especially of large size.

THE COST OF STEAM POWER.

From "Engineering."

Although in the vast majority of cases where steam power is employed, it is an object to obtain it at the least possible cost, yet we but comparatively rarely find an instance in which more economical results could not have been obtained by the exercise of competent judgment in the choice of an engine and its accessories in the first place. This may appear to be a somewhat broad assertion; but it is, nevertheless, one amply justified by facts which are open to the consideration of all who choose to seek for them. In most of our more important water-works, at many of our mines in Cornish districts, and at a small number of our larger factories, where the whole of the arrangements have been left to a competent engineer, may be found steam power supplied at an economical rate; but these instances are exceptional, and form but a very small percentage of the whole number of cases in which such power is employed.

The fact is that but very few users of steam power recognize the numerous items of which the cost of such power is made up; while a still smaller number give any consideration to the relations which these items bear to each other, or to the manner in which the economy of any given engine is effected by the circumstances under which it is worked. Very many people—and people who ought to know better too—imagine that an engine which is good for one situation is good for all, whereas a greater error than such an assumption can scarcely be imagined. It is true that there are certain classes of engine which may be relied upon to give moderately good results in almost any situation; but where the *best* results are desired—and the best results always *should* be desired in planning a factory—there are a considerable number of details which must be taken into consideration in making a choice of an engine. To the principal of these considerations we now propose to direct attention, premising that our remarks are intended to apply to the choice of engines for what may be called permanent use, as, for instance, at a mill or factory. The case of engines intended for temporary employment only, is an entirely different one, and we may perhaps have something to say about it on a future occasion. We shall also suppose for the purpose of simplifying the matter as much as possible, that it has been determined that the work of the mill or factory for which the motive power has to be chosen can be best performed by a single engine. The question of how far it is advisable to divide the total power required amongst a number of engines, for the purpose of saving shafting and for general convenience, is of itself a most important one, and demands independent consideration.

The expenses which go to make up the cost of steam power may be divided into six items, each to a certain extent dependent upon, and each, also, to a certain extent independent of, the others. Thus we

have, firstly, the interest upon the cost of the engine, boiler, engine and boiler houses, and accessories; secondly, the charges for repairs and depreciation; thirdly, the cost of attendance; fourthly, the cost for lubricating materials and miscellaneous stores; fifthly, the cost for water; and sixthly, the cost of fuel. Now in choosing an engine for the performance of any given work all these independent items should be carefully considered, and the object sought should be to make their sum total as small as possible, due regard being of course paid to the nature of the work to be performed.

The first item we have mentioned, namely, the interest on the first cost of the engine and accessories, may itself be subdivided with advantage into the amounts of interest on the respective costs of, firstly, the engine and boiler houses; secondly, the foundations for the engine; thirdly, the engine; and fourthly, the boilers. In some cases—as for instance the pumping stations connected with the Metropolitan main drainage, and other works of a national or exceptionally important character—it is not only justifiable, but praiseworthy, to sacrifice a certain amount of first cost for the sake of obtaining a good architectural effect in the buildings containing the engines and boilers; but inasmuch as we consider that the interest on the extra outlay thus involved is not fairly chargeable to the cost of the steam power, we shall say nothing further about it here, and shall consider engine and boiler houses merely as affected by the class of engines and boilers they have to contain. Here, then, we come to the first point in our choice, namely, the *form* of engine to be adopted. In some few cases—as for instance where engines have to be placed in confined situations—the form is practically fixed by the space available, it being perhaps only possible to erect a vertical or a horizontal engine, as the case may be. These, however, are exceptional instances, and in most cases—where large powers are required at all events—the engineer may have a free choice in the matter. Under these circumstances the best form, in the vast majority of cases where machinery has to be driven, is undoubtedly the horizontal engine, and the worst the beam engine. Properly constructed, the horizontal engine is equally durable with the beam engine, while its first cost is much less; it can be driven at a higher speed, and it involves a much smaller outlay for engine house and foundations than the latter. In many respects the horizontal engine is undoubtedly closely run by the best forms of vertical engines; but, on the whole, we consider that where machinery is to be driven, the balance of advantages is decidedly in favor of the former class, and particularly so in the case of large powers.

The next point to be decided is, whether a condensing or a non-condensing engine is to be employed, and if the former, whether an ordinary injection or a surface condenser should be used. In settling these questions, not only must the respective first costs of the two classes of engine be taken into consideration, but also the costs of water and of fuel. Excepting, perhaps, in the case of very small powers, and in those instances where the exhaust steam from a non-condensing engine can be turned to good account for heating purposes, it may safely be asserted that in all instances where a sufficient supply of condensing water is available at a moderate cost, the extra economy of a well-constructed condensing engine will fully warrant the additional outlay involved in its purchase. By employing steam of a very high pressure, a well-constructed non-condensing engine can, no doubt, be made to approximate closely to the economy of a condensing engine supplied with steam at the pressures usually adopted in mills; but in this case the extra cost of the stronger boilers required will go far to balance the additional cost of the condensing engine. It may, however, happen that there is a scarcity of water for condensing purposes, and that if a condensing engine is employed, either an extra supply of water will have to be paid for, or cooling ponds provided. Of course, if this is the case, these matters must all be taken into consideration in making the choice.

Again, it may happen that, although there is a plentiful supply of water of some kind, there is a scarcity of water suitable for feeding boilers; and it is in a case like this that a surface condenser is especially applicable; while in some cases, where there is a scarcity of water of all kinds, an air-surface condenser will do good service and effect an important economy.

Supposing now the form of engine to

be fixed upon, it remains to be decided what "class" of engine shall be adopted; and by the term "class" we here mean the relative excellence of the engine as a power-producing machine. Of course an engine with steam-jacketed cylinder, expansion gear, etc., costs more than a lower class of engine without such apparatus, and it depends upon the cost of fuel at the place where the engine is to be worked, and the number of hours per day it is kept running, which class of machine can be adopted with the greatest economy to the proprietor. So long as a certain form of engine is adhered to, the cost of foundations, engine-house, and general accessories, will be the same whether the engine is of a high or low class, while the cost of attendance will also be practically the same. The cost of lubricating materials, fuel, repairs, and percentage of cost to be put aside for depreciation, will all be less in case of the high-class than in that of the low-class engine, while the former will also require less boiler power. Against these advantages are to be set the greater first cost of the high-class engine, and the consequent annual charge due to capital sunk. These several items should all be fairly estimated when an engine is to be bought, and the class chosen accordingly. Let us take the item of fuel, for instance, and let us suppose this fuel to cost 10s. per ton at the place where the engine is to be worked, this price including the cost of stoking. If, now, the engine is run the usual number of hours per week, it will, as we have already stated, consume about 1½ tons, or 15s. worth, of coal per horse power per annum for each pound of coal per horse per hour. To be really economical, therefore, any improvement which would effect a saving of 1 lb. of coal per horse power per hour must not cost a greater sum per horse power than that on which the 15s. saved would pay a fair interest. Supposing, for instance, that a mill proprietor estimates his capital as worth to him 10 per cent. per annum, then the improvement which would effect the above-mentioned saving must not cost more than £7 10s. per indicated horse power, and so on. If, instead of being run the usual number of hours per week, the engine is run night and day, then the outlay which it would be justifiable to make to effect a certain saving per hour would be doubled, for the annual total saving would also be doubled; while, on the other hand, if an engine is run less than the usual time per week, a given saving per hour would justify a corresponding less outlay.

It is for reasons such as we first pointed out that it is impossible, without considerable investigation, to say what is really the most economical engine to adopt in any particular case; and as comparatively few users of steam power care to make this investigation, a vast amount of wasteful expenditure results. Although, however, no absolute rule can be given, we may state that the number of instances in which an engine which is wasteful of fuel can be used profitably is exceedingly small. As a rule, in fact, it may generally be assumed that an engine employed for driving a mill or factory cannot be of too high a class, the saving effected by the economical working of such engines in the vast majority of cases enormously outweighing the interest on their extra first cost. So few people appear to have a clear idea of the vast importance of economy of fuel in mills and factories that we perhaps cannot better conclude this notice than by giving an example showing the saving to be effected in a large establishment by an economical engine.

Let us take, for instance, the case of a mill having engines which require 35 lbs. of water to be converted into steam per indicated horse power per hour; this being a moderate amount as things go and requiring a so-called "good" engine. If now the engines in this mill indicate 300-horse power and work 24 hours per day for 300 days in the year (and there are many mills where the engines do this), they will require 75,600,000 lbs. of feed water evaporated per annum; and to do this in London, or districts where coal is equally dear, would cost about £4,000 annually. If now, in place of the engines we have supposed above, the mill was fitted with others, of a high class, such as that we illustrate on page 5 of the present number, the quantity of water which would be necessary to evaporate would not exceed 22½ lbs. per indicated horse power per hour, and the total annual quantity would thus be reduced to 48,600,000 lbs. To evaporate this quantity under the same circumstances as we have before supposed would cost but £2,570 per annum, and there would thus be an annual saving of

£1,430 available for interest on the extra first cost of the better engines. But, as we have already stated, the cost of foundations, engine-house, and accessories, would be the same for the high class as the lower class engine, while the former would require less boiler power, there being less water to evaporate, so that the difference in the first outlay would really be rather less than the mere difference of cost of the two engines themselves. For this difference of cost in the case of engines of 300 indicated horse power, £1,430 would certainly be an ample allowance, and the difference would therefore, in the case we have supposed, be paid off in a single year by the saving of fuel effected by the better engines.

Supposing, now, that after the first year the annual saving of £1,430 is invested every year at 5 per cent. compound interest, then the mill-owner will be richer at the end of ten years by £15,767, at the of twenty years by £43,672, and at the end of thirty years by £82,120, than he would have been if he had gone on using the engines requiring 35 lbs. of steam per indicated horse power per hour. In other words, he would simply, by sinking £1,430 for one year, have accumulated, during the succeeding thirty years, nearly *ninety thousand pounds;* and not only this, but he would, during that time, have had his mill driven by engines which would be more cheaply kept in repair, and be less liable to give him trouble by break-downs, than those of an inferior class. We have, in the above comparison, supposed the less economical engines to use 35 lbs. of steam per indicated horse power per hour, but this is a very moderate allowance for ordinary mill engines, and the majority of such engines use from 45 lbs. to 50 lbs. of steam per indicated horse power per hour. In such instances the saving we have shown to be effected in the economical engine would be doubled, while in the case of such engines as that at the Ryesholm pit, Ayrshire, on which Professor Rankine made the experiments described on page 300 of our last volume—an engine which, even after being fitted with a Morton's ejector condenser, used 55.2 lbs. of steam per indicated horse power per hour—the saving would amount to three times as much as we have assumed in the foregoing calculations, or £4,290 per annum. Invested at 5 per cent. compound interest, as before, this annual saving would amount in 10 years to £47,301, in 20 years to £131,016, and in 30 years to no less than £267,360! Let users of wasteful engines bear these facts in mind.

PUMPING MONEY.

From "The Engineer."

However singular and startling the above heading may appear, it accurately indicates the nature of the final process in the art of money-making, as practised at the Mint of Great Britain. Without entering into a detailed account of the manipulatory operations by which ingots of gold are transformed into sovereigns, it may be stated that the finishing touch which gives them their impressions and their milled edges, is always administered through the medium of an air-pump. Every coin of this, and indeed of other denominations which have emanated from the Mint since year 1810, may therefore truly be said to have been pumped into the circulating channel. The pneumatic arrangement by which letters or postal packets are pumped through underground tubes from the General Post-Office to Euston-square Station is but a modification of the pump and cylinder system of money stamping in force at the Mint. Should the atmospheric mode of letter carrying be extended to other districts of London as is suggested, the air-pump will become at once our general postman and chief coiner.

Let us proceed to explain the means and contrivances by aid of which the operation of pumping sovereigns is performed on Tower-hill. The prime mover is a steam engine, of 20-horse power, on the combined high and low pressure principle, and which was erected by the Messrs. Rennie. Originally this was intended for pumping water from a deep well to supply the establishment. In 1851, however, Mr. Newton, the Mint engineer, proposed that the engine should be made to pump coins

as well as water, and showed how the thing could be done. The plan was approved by the authorities of the place, and, under the inspection of its inventor, the Messrs. Rennie realized it.

An air-pump constituted the great feature of the scheme. This was made on a new principle, and, while of very simple construction, is found to work with great smoothness and efficiency. It consists of a cast-iron cylinder closely resembling that of an ordinary steam-engine in external appearance. Internally it is very different. The piston is solid, but surrounded by rings of cast-iron, pressed outwards so as to fit the cylinder by the action of steel springs. The base of the cylinder is a hollow casting of iron, or box, and so is its cover. These boxes contain the valves. In each there are 64, and they are necessarily of small size. They are, in fact, nothing more than narrow slips of saw plate, each covering a slot or aperture, and screwed, at one end, to the seat. In both upper and lower boxes 32 of these miniature and silent valves open to the atmosphere, and 32 to the exhaust or vacuum tube. The pump is 42 ins. in diameter, and the piston has a stroke of 36 ins.

By this arrangement of valves, etc., the pump, which is worked directly from the main beam of the engine, is made double-acting; that is to say, it exhausts air during both the up and the down stroke of the piston. A pipe, 200 ft. in length, connects the air-pump with the coining-press machinery. The communication is made over the roof of the building, and therein differs from the pneumatic letter tubes referred to, and which are carried underground. The cost of the whole contrivance, with its accessories, was not more than £400, and after 17 years' working, during which time it has saved the country upwards of £3,000, it has never once got out of repair. Its inventor received *thanks* for his ingenuity, and nothing more. The connecting pipe of the air-pump dips at the proper point through the roof, and is extended downward to a vacuum chamber. This is a cylinder of cast-iron 50 ft. long, and 30 ins. in diameter. It rests horizontally on the floor of the Mint pump-room, and in a line parallel to that of the eight coining presses. Along the top of the vacuum chamber, and each supported by a pipe opening into it, are ranged eight small cylinders without covers. These are furnished with pistons packed with leather, and are placed vertically. Rods, horse-head cranks, and levers, all of light contruction, connect the pistons with the central screws of the stamping presses. It will now be understood that once the air is pumped from below the pistons these latter will descend by force of the atmospheric pressure on their surfaces. They do so really when the great air-pump is in action, and valves below the piston are made to open to the vacuum chamber; the air within the cylinders then rushes down to the exhausted tube, and is discharged again into the atmosphere, whilst the pistons descend to the bottoms of the cylinders, and drag after them the main screws or strikers of the presses. The instant that the dies—one of which is affixed to each screw—advance towards those resting below them, discs of gold are interposed by self-acting machinery, and enclosed by milled collars of hardened steel. By the force of impact resulting from the pistons falling in vacuum, as described, the blanks sustain heavy blows from the upper dies, which thus communicate the impressions that afterward are so much admired. The steel collars form moulds which serrate or indent the edges of the coins, and preserves their circularity whilst being struck. The press screws then rebound, carrying up their respective pistons. The pneumatic valves again open, the dies descend upon new blanks furnished by mechanical fingers. Another batch of sovereigns is pumped into existence, and so long as the air-pump is exhausting the chamber, and fresh blanks are forthcoming, streams of coins, glittering like beetles' wings in the sunshine, will flow down from the presses into reservoirs arranged to intercept and make them prisoners. Thus it is that from day to day, during a gold coinage, the operation of creating sovereigns is carried on at the Mint, and thus it has happened that the Newton air-pump has caused one hundred millions of them, weighing in the aggregate more than a thousand tons, to be added to the gold currency of the world. "Pumping sovereigns by wholesale" would, therefore, be by no means an inappropriate title for the present article.

Before concluding, we would desire to offer a simple suggestion to the Chancellor of the Exchequer. It is this, that in-

stead of carting coins through the streets from the Mint to the Bank of England, or the metal for making them from the latter to the former place, the transport should be effected underground. The distance between the two establishments is not great, and there would be no engineering difficulty and little expense to be incurred in connecting them by means of one or two pneumatic tubes. Probably an up and a down line would facilitate the transit of the precious materials, and another of Mr. Newton's air-pumps, of proper dimensions, is all that would be required in the shape of additional machinery. The present mode of transit is both primitive and unsafe. That which we propose is at once scientific, practicable, economical, and perfectly secure. It is to be hoped that the idea now promulgated may be adopted forthwith by the Government. At any rate we assert fearlessly that its realization would be of infinite advantage to the Bank and the Mint, and at the same time a source of great satisfaction to the public at large. It would form, also, a valuable extension of the system of "pumping sovereigns."

THE WORKING AND VENTILATION OF COAL MINES.

From "The Mining Journal."

Mr. J. Warburton read a paper at the Manchester Geological Society, on Tuesday, on the working and ventilation of coal mines. In the course of his remarks he said that the long-continued depression in the coal trade had forced upon all producers the necessity of economy in order to get a market at all, even sometimes at unremunerative prices. So much had this been the case during the last two years, that he believed a good many capitalists were diverting their money in other directions. Very nearly three years ago he had the honor of reading before this society a paper on what seemed to him to be the best methods to produce coals in a marketable condition, in which he confined himself to the method of getting coal. In this paper he proposed filling in the details as respected the whole of coal production, taking into account ventilation, transit, and all the concomitants of coal producing. He would only say of sinking, that he never yet met with a shaft too large, but he had seen many too small. One other important point he had seen frequently overlooked—namely, the accomodation at the bottom of the shaft. Where a shaft is expected to have drawn through it from 500 to 1,000 tons per day, and must work uninterruptedly 8, 9, or 10 hrs., a good deal of convenient storage room was required at the bottom. He had seen several important collieries seriously crippled at this point; yet going on without this heavy drawback to their efficiency being recognized. After some remarks on underground haulage, in which he expressed a preference for the use of endless chains, he continued: "But there are many collieries where no kind of steam power is applied, but all the haulage done by manual and animal labor. In some of these collieries the haulage expense is very high indeed. It cannot be otherwise where men and boys alone are employed to do this kind of work, and in several places of medium pretensions no other power is employed. I have heard it used as an argument against the introduction of ponies even, that certain seams were too thin to admit them, and with some people this is a fatal objection. With regard to the employment of ponies, small ones are generally secured for collieries, and sought by owners for that purpose. It appears to me that policy is fallacious. If a seam has to be worked, and will pay to get the coal out by small tubs and low roads, will it not pay much better to make high roads and use large tubs? I should say most decidedly it will. So, with regard to ponies, it is much more economical to have one that can draw 16 tubs instead of one that can only take 8 at one time. One lad can do for the former, and less than a lad cannot be employed with the latter. In any case, I would say, let there be large roads, and where animal power is used, large horses, and, in all cases, large tubs. For such is the perversity of underlookers and deputies, that, however large or however small the ponies and tubs, you will be sure to find many roads just sufficient for the tub to go, and no

more. No man or animal can exert his strength in a small space.

A word or two on tubs, corves, or trains. In various parts of the country, there are different kinds and shapes of tubs, some in keeping with the principle of their work, others made regardless of the nature of what they are to do. In South Wales, the Midland Counties, and some places in the North of England, they have wagons much more in keeping with the principle of their work. In Lancashire and Yorkshire we seem to make them as nearly square as we can get them, as if they had to travel sideways as well as endways, thus giving ourselves a broad end for resistance against friction, instead of having the same resistance only for a wagon some 18 ins. to 2 ft. longer. The resistance is not the only drawback. When made nearly square the tubs are much more liable to get off the rails, and much more easily tipped over on the roads if the wheels or axles come in contact with any obstruction. The position of the wheels to each other is also a matter of more importance than is generally supposed. At two separate collieries where I advised an alteration of this kind, the objection raised by both the surface manager and underground steward or underlooker in both places was the same, —by the surface men, that the corves would not twist round so easily if the wheels were further apart; by the underground men (*i.e*, underlookers), that the corves would not lift on the rails so easily when off. These details, to such a society as this, may appear trifles; but it is these trifles in the working of a colliery that go to make up the economy or otherwise. I will give a single instance of the importance of these seeming trifles. I am acquainted with a place where, at one of the pits, up to the end of 1865, they had never been able to draw more than an average of 1,800 tons per week; but by attention to details such as are named in this paper, a weekly average of 3,500 tons were being drawn with ease at the end of 1866. Economy can never be attained with low, bad roads, badly made tubs or wagons, the transit done by manual labor, or even small ponies. I have for some time seen that a great amount of risk and danger is incurred by a too free use of prop wood near the face coal. The true use of prop wood is very little understood. If props at or near working faces are used for anything but temporary purposes, they are expected to do what they cannot do. The sooner, after the coal is taken away, we can let the roof fall the better it is in every respect, both for safety and keeping the next length in better condition. Sprags to keep up the coal till properly holed, and props sufficient to form one or two rows lineable with the working face, are much better than a large quantity set here and there, or any where.

The getting of coal in its most marketable condition should not be sacrificed at the expense of getting the quantity cheap. Economy should be aimed at with this standard in view—that a certain fixed percentage must be in the most valuable condition. This should be the first consideration, and how to do it requires a good deal of skill and judgment. Few will dispute that the largeness of the coal is one of the conditions that constitute value. Also that this largeness should stand transhipping and conveying to its destination with as little depreciation as possible. There is a common expression among coal carriers and colliers in Lancashire that a "square dog-headed coal" is the best for standing knocking about—the expression meaning somewhat of a rhomboid shape, and being intended to convey a distinction between that and the thin laminated coal so easily broken during transit. As a rule, we might say that to get coal as described requires that the coal should be worked at right angles to the cleavage, be holed well and deep, and, if possible, got down by its own gravity, instead of shaking it to death by blasting. Having decided to get the coal in the best manner possible for the market, the next thing is to get it as economically as possible. In my opinion the fixed prices and the mode of fixing them appear to be erroneous. I have known the mode for a quarter of a century, and the same scale obtains now as it did then, though labor, appliances, and all else have altered very much during that time. In Lancashire, as a rule, a coal-getter is everything almost connected with getting, and frequently performs the whole process of preparing—or holing and cutting—the coal, getting it hown by hammer and wedge, or blasting, as the case may be, breaking it out, filling it, and even taking it to the shaft or portway. There seems to me to require

a much wider division of labor. The man who does all may be efficient in all, but he can scarcely be expert in any one of the duties. Amongst our economy we ought to economize the labor of the coal-getters. There are many men old and disabled at 34 years of age through working in strait work. To work economically, in my opinion, would be to work with all the face open, and have neither strait work nor fast boys. I would have the face open all round if need be, and dispense with any cutting whatever. Work at right angles to the line of cleavage. Divide the work; one set of men having to do nothing but holing, another loading or filling, the responsible man having to take down the coal, set the props, draw the back ones, and see to the safety of the place; another set of men to take the roof down in the wagon road, and do the packing at the road sides; and bring a horse to a shunt kept close up to each working place. The first operation after the place is ready is to prepare the coal by holing, which is a very important matter. In Lancashire this holing is done generally at the bottom of the seam, in the coal itself; and, as holing has never formed a separate division or branch, it is done very imperfectly. The colliers of this county are not brought up to deep holing, and what is done has to be done at a great sacrifice of coal, as they "snape" the coal so much to get under at all. If they go three quarters of a yard, the front of the holing must have an opening of from 18 in. to 2 ft. The amount of coal I have seen cut away in this manner is incredible. It is this kind of holing that necessitates the use of so very much powder to get the coal down. When the coal is opened out in long faces, or long wall proper, there is very little difficulty in finding some thin bed of dirt about the bottom to hole in. Even if it were 18 in. thick I would hole in it, and have the whole got up and cast behind the men into the gob, and leave the coal intact. If well spragged and holed 4½ ft., 5 ft., or 6 ft. under, and backed up at the far end of the holing, the whole may be got down in large coal, and, as a rule, without powder, as its own weight will bring it down. Blasting in coal getting is a very unprofitable expedient, apart from the risk that attends it both to men and owners. Where a great deal of powder is used the value of the coal is very much depreciated thereby. Therefore, it cannot be economical to blast coal. Of course there are exceptions, but they would be rare. It is a well-known fact that the least capable men in any colliery use the most powder, and as a consequence produce less valuable coal. Not the least part of economy in getting coal is to get it clean out—that is, leave none in the pit. It has always seemed to me a reflection on the mining faculty, that in computing the amount of coal in a seam it is usual to strike off something like one-fifth of the whole as likely to be lost in pillars or other waste. In seams of ordinary and usual thickness, I see no reason whatever that the whole coal should not be taken abreast of the colliers, clean outright before them. Where pillars are left, to be gotten some other time, they are crushed and broken into slack, and very rarely indeed got out; and pillar getting is always attended with very great danger to the men.

I must conclude with a few remarks on the all-important question of ventilation. To ventilate economically means to ventilate efficiently. It is well known to those who have thought on the subject, that for a colliery to explode there must be a deficiency of good air; there must, too, be much light carburetted gas, and in this condition the mixture must come in contact with flame or fire, and the more this fact is pressed upon those having charge of collieries the better will it be for all. If we were all taught, and thoroughly believed, that collieries could be properly ventilated, I am convinced we should have fewer large explosions; but so long as we can persuade ourselves and the public that an accidental mis-shot can fire a whole pit, so long are we liable to these dire misfortunes. I do not say that a shot cannot fire a pit; but I do say, except there already exist the elements of combustion to very nearly an inflammable point, a shot cannot fire a pit. I am perfectly free to acknowledge that a mis-shot may do a great deal of harm in a confined place, such as the straight work commonly driven in Lancashire; but it seems very unsatisfactory not to be able to account for it. As many serious explosions have occurred simultaneously with the explosion of a heavy or mis-shot, there is a connection, if we could satisfy ourselves what that is. I have given it some thought,

and strongly incline to the following idea: That a mixture of gases just below exploding percentage would become explosive when suddenly compressed. Such compression, I believe, a fast shot capable of producing, and bringing that gas to an explosive point which previous to this sudden compression was not so. This, I think, would take place in the immediate vicinity of such a shot, and the fire that caused the sudden compression would ignite the gas around it, this ignited gas taking up the character of compression and igniting till the whole air, with only one-thirtieth of carburetted hydrogen even was consumed, thus causing a general conflagration in a colliery where the fireman would say, with truth, that he could have taken his lamp top off without fear of an explosion. This could take place only in a colliery very imperfectly ventilated. It is matter of surprise to me that, with the present state of mining knowledge, collieries are to be found with a great amount of capital at stake so badly ventilated; indeed, there are places now working, and ventilating on such systems, that must sooner or later result in an explosion. It is now more than seven years since I suggested for colliery owners such an association for their mutual benefit as the Association for the Prevention of Steam-Boiler Explosions, and I still think it would be of immense advantage. A proprietor would get to know when his colliery was in danger, which is not always the case now. Working on the end of the coal has a special advantage as regards the ventilation. Cutting across the coal is like opening the ends of hundreds of small tubes, and thereby letting out the gas. This is one very great advantage I claim for working coal on end. By such a system we are much less liable to sudden outbursts, as the tubes are always open and drinking the gas from the body of coal. I have prepared a plan by which the cold wind goes direct to the working face, no doors or bratticing in the way; it has no circuitous air-courses to go up and down; it is upon its work at once; and it passes some 150 yards of the face of the working coal, having no other course than that, then retires into a return. There is something special about these returns, as they are all made through the waste, or are made like the other gates or pack roads as we proceed; but there are certain cross roads communicating with the returns from the goaves. These are kept open as indicators, for I find at these places the barometric pressure is less than anywhere else in the pit, and if there is gas in the goaves, sooner than come down on the men at the face it will come at these places, and, being nearer the upcast, drain off, and never come near the men at all. The Oaks was long wall, and on end; but their lowest point of pressure was at the face where the men were working; consequently when the barometer fell the gas came upon the men from the goaves—and, in fact, that was its only outlet. This kind of ventilation is very objectionable. The system also of leaving the goaves behind is open to the same objection, as the lowest point of pressure is where the men are working.

Russian Exhibition of 1870.—The official paper publishes the following notice to intending exhibitors:—"By the terms of the Articles 11 and 12 of the Regulations of the Russian Exhibition of 1870, private individuals, administrations, and societies who wish to exhibit manufactured articles are requested to send a written notice to the principal Commission, or to one of the auxiliary committees, drawn up in the form prescribed, as soon as possible, or, in any case, previous to the 1st of January. The construction of the building being completed, the internal arrangements with respect to the division into classes and so forth are now under consideration, consequently the Commission has the honor to request persons and institutions who desire to compete in the Exhibition to send in their written notices with as little delay as possible, in order that the allotment of space may be proceeded with as speedily as possible. The Commission particularly wishes to have immediate notice with respect to machines that are going to be sent, and of those which it is intended to work in the Exhibition; also of objects which from their weight or volume require special positions and a great deal of space. Printed forms and declarations to be sent with the articles for exhibition may be obtained free of charge at the office of the Commission." Another official notice announces that auxiliary committees have just been formed at Helsingfors, Riga, Yaroslaf, Vladimir, Taschkend, and at Nijni-Novgorod.

MECHANICAL ENGINEERING IN 1869.

From "Engineering."

In these days of railways and iron structures it would be a difficult, if not indeed a hopeless task, to attempt to lay down precisely the line of demarcation separating "civil" from "mechanical" engineering. "Once upon a time," as the old fairy books say, each of these branches of our profession had its own tolerably defined and well-known limits; but that time has passed away, and although broad distinctions still exist, there has arisen—as iron has become more and generally used in engineering works—a broad neutral ground common to civil and mechanical engineers alike. It is not, however, of matters occupying this debatable tract that we intend to speak in the present notice; but rather of those which come strictly within the province of the mechanical engineer, such for instance as tools and labor-saving contrivances of various kinds, and we, moreover, propose to confine our attention to subjects not included under the classes of agricultural or railway engineering or steam engine construction, preferring as we do to treat of these matters independently. Even, however, after these deductions have been made we find that mechanical engineering embraces an extremely wide range of subjects to which it is impossible, within the limited space at our disposal, to do the justice they deserve. On all sides, and in almost all branches of manufactures, we find that mechanical engineers have made *some* progress during the past year; this progress, of course, consisting in many instances, merely of improvements in minor details, while in other cases new fields have been opened for mechanical labor.

Commencing underground, we find that coal-getting machinery has not only in a great measure outlived the prejudices against it, but is beginning to take up an important position amongst mechanical contrivances. Whether "pick" machines or machines in which the cutting of the mineral is effected by a direct planing action give the most economical results, is, however, yet to a certain extent an open question; but we anticipate that it will ultimately—in most situations at all events—be decided in favor of the latter class. Besides the coal-cutting machines proper, of which several new examples—Davies's and Hurd's amongst others—have been brought out during the past year, much attention is now being paid to the use of wedges or hydraulic machinery, as a substitute for gunpowder, for "breaking down" the coal. Mr. J. Grafton Jones, Mr. C. J. Chubb, Mr. D. Davies, Mr. Craig, Mr. S. P. Bidder, Jr., Mr. Cochrane, and Mr. Farum have all brought forward contrivances for this class of work, and with some of them very excellent results have been obtained. Mr. Jones's apparatus consists of a number of plungers set side by side in a steel bar, the plungers being forced outwards, against the sides of the hole in which the contrivance is placed, by hydraulic pressure. Mr. Davies also employs a set of plungers arranged like Mr. Jones's, but he makes the bar flexible by dividing it into lengths jointed together; while in Mr. Chubb's arrangement a set of hydraulic plungers are caused to force apart the bar in which they are set, and another bar forming a cover. In Messrs. Craig and Bidder's, Mr. Cochrane's and Mr. Farum's arrangements, on the other hand, wedges are employed to give the spreading action, Messrs. Craig and Bidder employing hydraulic pressure, Mr. Cochrane screw power, and Mr. Farum the force of percussion, to bring these wedges into action. One great objection at first raised to the use of contrivances of the kind of which we are now speaking, was the difficulty which existed in boring at a moderate cost holes suitable to receive them; Mr. J. G. Jones and Mr. Chubb, however, have each brought forward during the past year arrangements of boring apparatus, calculated to get over this difficulty. There can be no doubt that coal-getting machines of the class above mentioned may be substituted for powder with great advantage, as regards safety of working, in a vast number of cases; but we certainly do not anticipate that they will entirely do away with the use of explosives in mines, nor are we quite certain that such machines can as yet successfully compete with powder, as far as mere economy of working is concerned. Economy, however, should decidedly be

deemed a secondary matter compared with safety in mine working as in other matters.

Closely allied to coal-cutting machines are those employed for rock boring, and in the use of these some advance has been made during the past year. Mr. Fothergill Cooke has, we understand, been making good progress at his slate quarries in North Wales with the boring machine contrived by Mr. Hunter and himself, this machine cutting a tunnel through the slate 6 ft. in diameter. Captain Beaumont's diamond rock-drilling machine, made by Messrs. Appleby, has also been doing good work in Wales, and Mr. Doering has brought out several important improvements in his rock-boring apparatus. Notwithstanding all this, however, and notwithstanding, also, the efficient aid which machinery of this kind has rendered at the Mount Cenis tunnel, and a few other important works, rock-boring machines are still far from meeting with the attention which is fairly due to them —a state of affairs in which we hope to have to chronicle a change next year.

The employment of machinery for stone-dressing is, we are glad to see, making some—although rather slow—progress; and Mr. Joseph E. Holme's ingenious and simple stone-cutting machine described by us in 1868 has during the past year been brought fairly into practical operation in a number of instances. Other machines and tools for saving the vast amount of hand labor expended—we almost said wasted—in working stone, have been brought out during the past twelve months, and there is ample evidence that this class of machinery is attracting the attention of inventors. Amongst others several new millstone dressing machines of more or less merit have lately made their appearance; but notwithstanding the immense saving of time and labor by this class of machine we cannot hear that they are being so readily adopted by millers as it was at one time anticipated they would be; a fact which is no doubt to some extent due to high royalty.

In the machinery of ironworks there has been scarcely any novelty introduced during the past year. Reversing rolling mills, driven direct by quick-running engines on Mr. Ramsbottom's plan, are, however, bidding fair to supplant the old cumbrous rolls with their fly wheels and gearing, while Mr. While's continuous rolling mills are also making steady progress. In the construction of steam hammers almost the only new feature which, so far as we are aware, has been brought forward during the past year is the use—introduced by Mr. F. W. Webb, of the Bolton Iron and Steel Works—of cast steel as a material for the standards and cylinders. We described Mr. Webb's plans in August last.

In the matter of engineers' tools the tendency is still to make heavier and more powerful machines. To a certain extent this tendency has been brought about by the more and more extensive use of steel as a constructive material; but besides this, the fact is now becoming generally recognized that heavy and powerful tools are a source of undoubted economy. A tool that will clear off in a single cut a quantity of metal that could only be removed by two or three successive cuts in a lighter machine, not only effects an important saving in time and attendance, but it enables a larger amount of work to be got through in a given area of shop room, and renders, to a great extent unnecessary precise and consequently expensive forgings. There are, indeed, a vast number of cases in which it is cheaper, where suitable machinery is available, to bring a rough forging to shape in a lathe or planing machine than it is to forge it more nearly to form under the hammer, leaving the machine tools but light work; and a knowledge of this fact is now being turned to good account in many of our most important engineering factories.

With the increased employment of heavy tools, the plan of driving each machine by a separate engine is gradually becoming more extensively adopted, and this is particularly the case with punching and shearing machines, and tools of a like character. There is also a prospect of hydraulic power being turned to account in this way, and it is not long since we illustrated an arrangement of hydraulic planing machine designed by Mr. Robert Wilson, and an earlier design for a similar machine, by Mr. James Fletcher.

Another feature connected with toolmaking, which has received considerable development during the past year, is the construction of machines adapted to special classes of work. It is scarcely possible nowadays to go through any

engineering factory of repute without noticing a greater or less number of machines which have been specially constructed for the class of work in which their owners are principally engaged; machines, perhaps, which would be of comparatively little service in another establishment, but which, in their proper places, effect an immense saving of labor. This is decidedly as it should be, and we expect during the next few years to find that these special tools will come more and more largely into use, and that they will, to a great extent, supplant machine tools of the ordinary standard forms. Another matter in which some progress has been made during the past twelve months, and in which we anticipate a more rapid advance in the future, is the adoption for many classes of work, of the copying principle. In our gun factories this principle has for some years past been turned to most successful account, and by its aid not only has great economy of production, but increased accuracy of workmanship been secured; yet notwithstanding this the application of the principle to the finishing of work of a heavier kind has made slow progress in this country. Of course the principle can only be economically adopted where large numbers of articles have to be turned out to one pattern; but even with this restriction there are vast fields for its employment. With the more extensive adoption of the copying principle must come the increased employment of the milling tools or revolving cutters so extensively used in America, and yet so comparatively little used here; while the increased employment of milling tools again will lead to the manufacture of new machines for making them.

In wood-working machinery there have been but few complete novelties brought out during the past twelve months, although many improvements have been introduced in machines already known. We must, however, make mention of Fraser's double-saw frame, lately described by us, and of Parkinson's "universal joiner"—a machine lately introduced by Messrs. Allen, Ransome & Co., and of which we shall probably give a description next week. Wood-machinery manufacturers, like engineers' tool makers, are gradually doing more and more in machines for special classes of work, and it is in these, in fact, that the principal novelties are to be found.

It would be impossible within the limits of an article like the present to even enumerate the names of the numerous new machines for miscellaneous purposes which have been brought out during the past twelve months, but at the same time there are many of them which it is equally impossible that we should pass over without notice. Foremost, perhaps, amongst these is Mr. James Lyall's admirably ingenious "positive motion" loom, which we fully described a few months ago, and which is now being exhibited at work in Manchester; while Taylor's tube-rolling machine, turning out metallic tubes at the rate of 60 ft. run per minute, is another important invention, of which a good deal more will yet be heard. Then again we have Messrs. Kittoe and Brotherhood's apparatus for sinking screw piles by steam power, Messrs. Shaw & Justice's gunpowder pile driver—both inventions calculated to do contractors good service in certain situations; Mr. John Cooke's simple mine ventilating machine; and, passing on to other labor-saving contrivances, Goff's wrist-pin lathe, Batho's nut-shaping machine, Crowe's universal tables for drilling machines, Burdett's brick-cutting table, Beeley & Hanson's welding machines, Halliday's and Daglish's arrangement for oiling colliery wagon axles, Michaud & Jay's automatic weighing cranes, and numerous other appliances of a similar class which we cannot even mention. Then, also, there is Aston & Storey's continuous indicator, one of the most ingenious inventions of the year, and one, moreover, which, if properly appreciated, will be of great benefit to all users of steam power.

We must now, however, bring this notice to an end, and in doing this we are fully sensible that we have by no means exhausted the subject of mechanical engineering progress during the past year. We have, however, we trust, said sufficient, when taken in connection with the independent articles which we intend to give on certain special branches of what we may term manufacturing engineering, to prove that our mechanical engineers have not been idle during the past twelve months, and that if trade has not been in a very flourishing condition, there has not been any lost ground on that account.

BUILDING MATERIALS AND APPLIANCES.

From the "Building News."

TERRA COTTA *versus* MASONRY.

The manufacture and uses of terra cotta have more than once been discussed in our pages from various points of view, and our readers will remember that strong opinions have been expressed with reference to the proper method of dealing with this material. As our title implies, we now propose to consider the relation it bears to stone work; for, after all, the main point which has to be regarded in connection with terra cotta is its future prospects in the competition with masonry, not merely for decoration but also for structural purposes. It may be as well at the outset to define what we wish to imply when we speak of the employment of terra cotta for the purposes of construction. We mean that terra cotta is too frequently looked upon as a mere fancy material, such as is papier-mache or carton-pierre, and its use is limited to window-dressings, spandrels, and similar decorative features—stone or iron being made to do the real work, while terra cotta is merely introduced for display. Now, we maintain that terra cotta is a genuine building material, just as much as brick or stone is; and in places where terra cotta cannot be employed, so as to do the work it professes to do by itself, it should not be used at all. It is quite as strong, if properly made, as brick, and by backing it in with cement it can be made to bear as much as Portland stone. There is not the slightest necessity for giving terra cotta cornices such a projection that they have to be held in place by York landings, or for making terra cotta columns hollow, and inserting cast-iron stanchions in the centre of them in order to take the weight; such shams as these are quite unworthy of the material. We desire, therefore, when we speak of its constructive use, to impress the fact that it should do the work it is represented to do, independently in any position in which it may be placed in a building.

If we go back to the early history of the revival of terra cotta in this country, about the commencement of the present century, we find that terra cotta was introduced about the same time as stucco and cast cement as a substitute for stonework. It then received numerous fine names, such as lithodypyra and lithargolite; but it was chiefly known as artificial stone. None of these grand names have survived, and it has come by universal consent to be called by the Italian word which signifies baked or burnt clay. Our object in reverting to the reappearance of terra cotta in England is in order to notice the circumstances under which it was ushered in, and to point out the difficulties against which it had at first to contend. The demand for terra cotta was then solely in the shape of shams or imitations of stone, such as keystones for the doors of the Harley-street period, consoles for windows, coats of arms for shop fronts, and all the pretty enrichments which the builders of that day considered necessary for their "first-class family mansions." Stucco, that most odious of all shams, was not then permitted to veil every defect and shortcoming in material and construction, and if the architecture was ugly, it was, at any rate, what it pretended to be. Now, it will at once be seen that terra cotta, commencing in the way we have described, began its career under false pretences; and it was most likely owing to this that in the struggle with stucco it was vanquished, and from the time of Coade until the Exhibition of 1851, we hear very little about it. Its failure may almost, however, be regarded as an advantage, inasmuch as the modern treatment of terra cotta, being based upon a better comprehension of the material, gives it a chance of a fairer and more reasonable trial than before. But we must not, as there seems some tendency to do, overlook the lesson which this defeat should teach us; and if terra cotta is to become an English building material it must be looked upon and treated as terra cotta, and not as artificial stone. As baked clay it has, in a country where brick is by far the most common building material, a strong claim upon our attention, and if honestly and properly made use of, there appears to be but little doubt of its being very generally employed.

We will now endeavor to show what we consider is the proper way of using terra

cotta. In one word we may explain this to be as a *brick*, or, better, as a superior kind of brick made of the finest and purest kind of clay, and specially calculated, on account of its durability and power of resisting discoloration, for the reception of such ornamental details as may be required in a brick building. It should be made, chiefly for manufacturing reasons, in small pieces, and in such size as will take up with a certain number of courses of brickwork. If larger than a brick it should be made hollow at the back or sides, in order that it may be well bonded in with the surrounding brickwork, and it should never be introduced into situations where these conditions cannot be satisfied; or, better, the architectural character of a brick building must be modified and fitted to receive brick decorations. We are persuaded, and we think that all must admit, that it is extremely wrong to employ terra cotta in places where it is necessary to string it or hang it out upon iron supports in order to give it an unnatural projection, or to plaster it in thin veneers of ashlaring against flat surfaces upon which it has no other hold than that of the cement in which it is bedded. If we refer to the Italian terra cotta work, we find that this common-sense method of dealing with the material is everywhere seen: in the Certosa near Pavia, the Ospedale at Milan, and the numerous brick buildings of Northern Italy. We question if any blocks over a foot could be found, and in the cornices and mouldings it was the universal practice to give an increased depth to make up for the want of projection.

Another common error with regard to terra cotta is the belief that, as it is a plastic material in the earlier stages of its manufacture, the blocks may be varied to any extent, and that it is possible to get any requisite number of changes of form without extra charge. Now, if we remember the way in which the blocks are produced, we can at once see the folly of this notion. Each change of pattern requires a fresh model and a fresh mould, or fresh moulds if there are many of each block, and it is not to be expected that manufacturers will introduce changes involving so much expense without extra charge, merely for the sake of variety. As a cheap material, the more blocks used of a pattern the better. We have frequently heard people say when alluding to terra cotta, that it possessed great advantages over masonry, inasmuch as you get the touch of the artist's own hand instead of the translation of it into stone or marble by the mason's chisel. But this, although true in a way, does not hold good with modern work so much as it might do. When the ornament is modelled in terra cotta clay, and then taken away and burnt, you do indeed get the untouched work of the designer; but if, as is more commonly the case, the clay model is cast in plaster and then moulded or piece-moulded, it too frequently happens that the reproductions from the mould undergo a scraping and finishing process with a sponge or a wash-leather, which is quite fatal to any artistic touch the original design might have possessed. There is, however, really no necessity for this dressing, and if the joints in the mould do leave little ridges on the blocks, we had far rather see them remain there than have them removed at the expense of the whole of the feeling of the design. It is hard to find so much fault, but as we have the interests of terra cotta warmly at heart, we must point out one other defect in the modern terra cotta—namely, in the design of the ornament for it. This blame will of course only fall indirectly upon the manufacturer, as he must be guided, to a great extent, by what suits the public taste in these matters, and any protest of ours must be addressed as much to the public as to him. We cannot but hope, however, that any alteration for the better in the design of terra-cotta work would be appreciated, for anything more hideous than the ordinary run of manufacturers' stock in this material cannot well be imagined. We are afraid even to commence to criticise the vases and garden ornaments one commonly meets with—they are beneath criticism; but even in the articles of a more architectural character in brackets, balusters, and enriched mouldings, one rarely meets with anything that is good. The tendency in terra cotta ornament is towards an indifferent cast-iron treatment, or a hard metallic-looking decoration, applied to debased Grecian forms which have in all probability been handed down from the earliest days of Nash, or even from the commencement of the Classic rage in George the Third's time, and are, in fact, nothing but servile copies of iron-work. Now, there is no

need of such bad design nowadays. We have amongst us a school of designers who are capable of better things, and we believe it would be worth any enterprising manufacturer's while to get some new models to replace the atrocities he is now guilty of. There is not the faintest pretext for making terra cotta so like cast-iron that if it were black-leaded, you would not know them apart; this is a fault quite as bad as the artificial stone treatment we have been complaining of. It is true that in both cases the work has to be moulded, but the mould used for terra cotta is widely different from that for iron. Under-cutting in terra cotta entails, as we must admit, rather more trouble than plain work; but to an experienced moulder there is less difficulty than one would imagine, while in the case of mouldings, which can be run out on the bench, it makes no difference at all. We may mention here that the method of running mouldings on the bench with a strickle, which saves an enormous amount of time and trouble, appears to be but little practised by manufacturers.

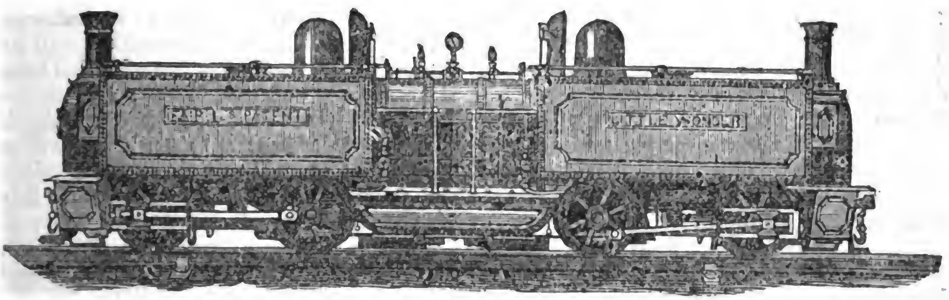
For architectural work the character of the design of the terra cotta is a most important consideration, and on this point we feel there can be little diversity of opinion. The relief of the ornament must never be obtrusive, or calculated to mar the outline of the surfaces to which it is applied; the lines should be flowing rather than stiff or constrained, as in iron chasing, and the feeling should be rather that the design has been wrought in a soft and plastic material than stamped, impressed, or cut out in a hard and unyielding one. We fear that in the effort to make terra cotta look crisp and nicely finished, this latter quality is too often attained by our manufacturers. We have as yet said but little, except by inference, about masonry, and we will endeavor, in conclusion, to show the bearings of our observations upon the special subject we proposed to ourselves. The point we would impress is, that for brickwork terra cotta is the proper decorative material, and that stone is just as out of place in a brick building as terra cotta is in a stone one. If it so happened that stone was cheaper than brick, we would still maintain this theory, but as this is not the case, we have a strong argument in favor of terra cotta. It is needless to induce reasons or precedent in support of this, as it depends upon a fact which can scarcely be questioned—namely, the relative fitness of these materials for the decoration of brickwork.

In the matter of price, we cannot too strongly urge upon manufacturers the necessity of producing terra cotta which shall be *cheap* as well as good. It is rather the way in the trade to make a great fuss about the composition of the ware, and to talk learnedly about powdered glass, calcined flints, pegmatite, etc., etc., even making a secret about the proportions of the constituents; whereas we can once and for all assert that the pure fire-clay of the coal measures is all that is necessary for the manufacture of a most durable and excellent material. There can be no great harm in adding the substances we have enumerated, it is true; but why have them in if the clay is just as well without them, especially when they are not forgotten in the price? Fire-clay, composed, as it is, almost entirely of silica and alumina, will stand the utmost heat to which it can be exposed in the kiln, and when once thoroughly fired such clay is almost imperishable. We have seen a specimen of fire-clay terra cotta, which has been for months in (commercially) pure oil of vitriol, the surface of which was perfectly uninjured and untouched by the acid. Well burned fire-clay is, if anything, less absorbent than a body composed of mixed materials, and certainly less so than Portland or the best of our building stones, granite only being excepted. It will be evident that in the case of plain mouldings, which can be run with a strickle, or simple enrichments, many of which will be required for each mould, there can be no comparison with stone in the matter of price, but even in the case of complicated designs, of which only one or two copies are needed, terra cotta can well compete with masonry in this particular. Perhaps one of the greatest arguments we can bring forward in favor of burnt clay is its beautiful and varied color. Instead of a grimy, soot-stained surface of stone or brick, we have a bright, non-absorbent material, which in color can be compared with nothing but marble, as seen in ancient buildings in Italy, where it assumes the richest and most varied tints,

and excels any English building stone we know of. We have thus noticed the advantage of terra cotta in the matter of fitness, of color, and of cost. It only remains for us to impress strongly on our readers these concluding points, to which attention must, we feel convinced, be paid, in order that terra cotta may succeed in the struggle for public favor. Manufacturers must learn that terra cotta can be produced much more cheaply than it has been up to the present time; architects must make themselves acquainted with its peculiarities, and with the best mode of dealing with them; and the public must find out, from a few good examples, that terra cotta is capable of being employed with excellent effect as a genuine constructive material, and, as such, of supplying one of our chief wants—namely, a good cheap decoration for our brick buildings.

THE "LITTLE WONDER:" FESTINIOG RAILWAY.

From "Engineering."



The seventh and last engine constructed for the 2 ft. gauge—the Festiniog Railway—was delivered some weeks ago, and is now working. As will be seen from the illustration, it is upon Mr. Fairlie's patent system. It has four cylinders, $8\frac{1}{8}$ in. in diameter, with 13 in. stroke and 2 ft. 4 in. (28 in.) coupled wheels. The tanks contain 1,000 gallons of water, and the whole weight, in steam, is estimated at about 20 tons. The total wheel base is 19 ft., each bogie having its wheel centres spaced 5 ft. apart. For each pound of average effective pressure on the pistons 60 lbs. of tractive force are exerted at the periphery of the driving wheels, or, with 100 lbs. mean effective pressure, a total force of 6,000 lbs. The "Little Wonder" is worked at a boiler pressure varying from 160 lbs. to 200 lbs., the boiler, of Sir John Brown's steel, being 2 ft. 4 in. in diameter, $\frac{3}{8}$ in. thick, and double riveted in the longitudinal seams. The engine easily hauls from 100 to 150 empty slate trucks up the line, or, say 100 to 150 tons, including its own weight, on a line, rising, on the average, 1 in 92, and occasionally 1 in 80. Nothing can exceed the steadiness of this engine in passing the curves of from $1\frac{3}{4}$ chains to 4 chains radius, and the speed already attained has been timed at 35 miles an hour.

The railway is the most wonderful one in the kingdom.

CHINESE SURVEYORS.—The processes of "levelling" are conducted by Chinese surveyors in a very primitive fashion: "The instrument employed is a modification of the water-level—an oblong trough of buckthorn or other similar wood, clamped with iron, and open at the ends. The interior surfaces of the sides are ruled horizontally with fine parallel lines in red or black paint, to serve as guides to the observer's eye. The trougo is suspended by a single cord from a hook fastened beneath the apex of a wooden tripod stand. The usual height of the latter is $4\frac{1}{2}$ ft. The instrument is adjusted by pouring water into the trough—which is deeper in the centre than at the extremities—and then shifting the suspending cord or the legs of the tripod until the surface of the water coincides with a pair of the horizontal lines."

PRESENTATION OF THE RUMFORD MEDALS.

From the "Boston Advertiser."

By a letter dated July 12, 1796, addressed to John Adams, Count Rumford requested the American Academy of Arts and Sciences to accept $5,000 in United States stock, the interest to be applied to premiums, to be given to the authors of the most important discoveries, or useful improvements, which shall be made in any part of the continent of America, or in any of the American islands, on heat or light; the preference always being given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind. To be given in two medals, one of gold and one of silver, together of the intrinsic value of $300. At a meeting of the Academy held in this city last evening, these medals were presented to Mr. George H. Corliss, of Providence, R. I., for his improvements in the steam-engine. The presentation was made by Dr. Asa Gray, President of the Academy, with the following remarks:

ADDRESS OF THE PRESIDENT.

Gentlemen of the Assembly,—At the last anniversary meeting, after a careful investigation by your appropriate committee, you awarded the Rumford medal to Mr. George H. Corliss, for improvements of the steam-engine. The gold medal and a silver duplicate have been struck and are now before us. The inventor, whose genius you have thus recognized, has responded to our call, and is now present. If it be your pleasure these medals will now be consigned to his hands.

Mr. Corliss,—The trust which our countryman, Count Rumford, charged this Academy to administer, empowered it to award these medals "to the author of any important discovery or useful improvement on light or on heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America or of any of the American islands; preference being always given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind."

As this is only the fifth occasion since the foundation of the trust, upon which this premium has been given, it may well be inferred that the Academy has in no case bestowed it inconsiderately.

It has required the discovery or invention to be real, original, and important. It is not restricted to considerations of direct practical benefit, but it may, as it did in the first instance, in the case of the oxhydrogen blow-pipe, honor a discovery of much scientific interest, the uses of which are limited. It would not hesitate to crown any successful, however recondite or theoretical investigation within the assigned domain, being confident that no considerable increase of our knowledge of the laws and forces of Nature is likely to remain unfruitful. But the Academy rejoices when, as now, it can signalize an invention which unequivocally tends to promote that which the founder had most at heart, and commended to our particular regard—the material good of mankind.

Without entering into details, it will be possible to state the ground upon which the present award has been made. It is for the abolition of the throttle-valve of the steam-engine, and the transference of the regulation by the governor to a system of induction-valves of your own invention; with the advantage of a large saving in fuel, and, what is often more important in manufacturing industry, the maintenance of perfectly uniform motion under varying work.

Previous to your improvements the regulation of the power and velocity of the steam engine was universally effected by an instrument placed in the steam pipe, well named the thottle-valve, being used to choke off the steam in its passage from the boiler, to reduce more or less its pressure before it was allowed to act within the engine. Avoiding this wasteful process, your engine embodies within itself a principle by which it appropriates the full, direct, and expansive force of the steam, and measures out for itself at each stroke, with the utmost precision, the exact quantity necessary to maintain the power required.

In the most approved engines previously used for manufacturing purposes, the valves employed were comparatively difficult to operate, too far from the piston, and in other respects unfit for working in connection with the governor. Their abandonment and the substitution of

others suitable for the purpose that you had in view, demanded an entire change in the structure of the engine.

In the reconstruction your mastery of the resources of mechanism is conspicuously shown; you introduced four valves to the cylinder, two for the induction and two for the eduction of the steam; and by your device of a wrist-plate you give to each valve a rapid motion in opening and closing, and a slow motion after the closing has been effected, thus securing a perfection in valve movements never before attained. The special object of these changes, and the gist of your invention, was to place the induction-valves under the control of the governor, by which they are operated in opening through a mechanism from which they are released earlier or later in the stroke of the piston, according as more or less power is demanded of the engine—the governor, with extreme sensibility, determing the point where the supply of steam should be cut off. Thus, at every stroke of the piston just so much steam is accurately meted out to the cylinder as is needed to maintain uniform velocity, and left to expand then, and by its expansion develop the maximum of propelling force.

Allow me to read to the Academy a brief account of the Corliss engine, by one of the most eminent of British engineers, Mr. J. Scott Russell, which must needs be free from personal or national prepossessions. It is from one of the official reports on the Paris Universal Exhibition of 1867 :

"A third remarkable engine is American, both in invention and execution, and forms perhaps the most remarkable feature of the American department. It exhibits thoughtful design, ingenious contrivance, refined skill and admirable execution. It is singularly unlike an English engine. It has four ports on four different parts of the cylinder, two on one end and two on the opposite, each worked by a separate mechanism. These ports are worked by valves, not sliding, like our own, on flat surfaces; but sliding valves on cylindrical surfaces. Close up to the cylinder these valves cut off the steam with scarce a particle of waste room, and so economize to the utmost the high pressure of steam which they admit, and which they use as expansively and as sparingly as possible. The mechanism by which these valves are moved, is to our eye outlandish and extraordinary; but it is, in truth, refined, elegant, most effectual and judicious; it spares steam to the utmost, but develops what it uses to most effect. Then it proportions in an admirable way the doses of steam it serves out to the continually varying quantity of work the engine has to do. The mechanism of its mechanical governor is wonderfully delicate and direct; the governor is sensitive to the most delicate changes of speed, and feels the slightest demand upon the engine for more or less work and steady speed. A mechanism, as beautiful as the human hand, releases or retains its grasp of the feeding-valve, and gives a greater or less dose of steam in a nice proportion to each varying want. The American engine of Corliss everywhere tells of wise forethought, judicious proportion, sound execution and exquisite contrivance."

It appears that within the twenty years since this machinery was perfected, more than one thousand engines of the kind have been built in the United States, and several hundreds in other countries, giving an aggregate of not less than 250,000-horse power ; that as to economy of fuel, evidence has been afforded to the Rumford Committee, showing a saving over older forms of engines of about one-third. As to its other crowning excellence, uniformity of velocity, the purchasers of one of the engines, now in its eighteenth year of service, certify that, with the power varying from 60 to 360-horse power within a minute, the speed of the engine is not perceptibly affected.

It is worth noting that when these medals were voted to you, Mr. Corliss, just a century had passed since James Watt patented his improvements of the steam-engine. The vast results of these improvements—the difference between the engine when Watt found it and when he left it—make one of the most important chapters in the history of applied science. It is a great thing to say, but I may not withhold the statement, that, in the opinion of those who have officially investigated the matter, no one invention since Watt's time has enhanced the efficiency of the steam-engine as this for which the Rumford medal is now presented to you.

If Watt, or his partner Bolton, could boast that they held the supply of that which almost everybody longed to have, *power*, you may justly felicitate yourself, and permit us to felicitate you, upon your ability to supply a greater amount of steam power for the expenditure, and an exacter nicety it its governance, than any of your predecessors.

In acknowledgment of this benefit, the American Academy, administering Count Rumford's trust, now, by the hands of its presiding officer, presents to you these honorable testimonials of its high appreciation of what you have done. And the Fellows here assembled, join with me, I am sure, in most sincere and hearty wishes that you may long enjoy this and similar distinctions, along with more material rewards of your genius and will; hoping, also, that these may still be fruitful in yet other inventions, redounding to your honor and advantage and to the promotion of the good of mankind.

Mr. Corliss accepted the medals, and replied as follows: "Mr. President: Competitive honors are the reward of efforts, stimulated by rivalry and ambition. This honor comes from gentlemen who scan the whole field of science and art, and in deliberate council make their awards in discharge of a sacred trust. To this consideration I add the historical associations connected with the American Academy of Arts and Sciences, and the scientific fame of its members; and I receive this testimonial with grateful acknowledgment of a distinguished honor."

BRIDGE CONSTRUCTION, 1869.

From "Engineering."

Bridge construction has been advancing rapidly during the past year, and principally in the United States. Nature has been kind to American engineers in giving them great obstacles to overcome, while necessity has rigidly limited outlay; and hence arises a special fertility of invention and a special class of work.

But Holland has been building large bridges too, and Russia is just commencing on a greater scale than any other European country. Hitherto her railway bridges have, for the most part, been made of timber, and are to be replaced. Especially on the Nicolai Railway, it has been recently decided to reconstruct sixty-eight wooden viaducts—a decision hastened through the destruction of one 1,200 ft. long by fire. Not much has been done as yet in Hungary, but last year saw the preliminary measures taken for a large amount of heavy bridge work in the future. The great bridge crossing the Hollandch Diep—the Waal and Maas estuary—to join Antwerp and Amsterdam by an unbroken line of railway, is in progress. The contracts for this work were let to Van Vlissengen and Van Heel, of Amsterdam, just at the termination of 1868, for a price of £122,260. The bridge is in 14 openings of 328 ft. each. A main line, undertaken by the State in 1860 for the purpose of connecting Belgium and France with the central part of Holland, has involved in its length the construction of 3 large bridges within a distance of 10 miles, over the Maas, the Lek, and the Waal, the two former of which are the channels by which the Rhine reaches the sea, and over which important bridges at Bommel and Crévecœur are in course of erection. The former of these, which is now on the point of completion, consists of 8 openings, each of 187 ft., and 3 of 393 ft. 8 in. Its cost has been £271,625. The Crévecœur bridge crossing the Maas has 10 openings, each of 187 ft., and one main span of 328 ft. This work, which has been undertaken for the sum of £93,000, will not be finished until the close of the present year. In the north of Holland, also, the railway between Zwolle and Leuwarden has been completed by the bridge across the Ysselin, 10 spans, one of which is 321 ft. 6 in. in the clear, the rest of the viaduct being made up with smaller openings, among which is a swing span of 51 ft. 6 in. in length.

Towards the close of the year a suspension bridge across the Moldau, at Prague, was opened for traffic. It is intended for foot passengers only, and is 629 ft. in length, the space being divided with a central pier. The width of platform is very inconsiderable, being only 11 ft. It is worth noting that the links forming the

suspension chains are of Bessemer steel; the contract price was £18,500.

In February last a stone bridge at Fucecchio, over the Arno, was completed. It consists of 5 arches of about 74 ft. each, and cost some £8,500.

The arched bridge of Bessemer steel which, it will be recollected, carried the Quai d'Orsay over the road between the Exhibition and the bank of the Seine, has been removed, and re-erected on its permanent site over the Vilaine, at Port-de-Roches. In its temporary position the arched girders, 11 in number, had one clear span of 82 ft., so as to obtain the necessary width. In its present position, however, it has been lengthened out into 3 spans, each composed of 4 ribs, giving a width between the parapets of 19 ft. 8 in. The total cost of the steel work of this bridge was but £2,612.

We have to turn, however, to America to find the great examples of bridge construction during the past year. The extension of railways westward, across the great rivers of the Continent, have involved much work; but two of the principal bridges are in progress to effect a metropolitan communication. Of these the first is that intended to connect New York city with Brooklyn, and will span the East River with a clear stretch of 1,600 ft. This was Mr. John A. Roebling's last and greatest work, at the first stage of which he lost his life. The bridge is, however, being carried out by his son, and when completed will be the largest in the world. During last year the caissons for the foundations have been partially built, and considerable excavation on the site of the piers is being carried on. When completed the towers will have a total height of 300 ft., and will carry the wire cables, from which will be suspended a double roadway for passenger and street railway traffic.

Second in importance is the arched road bridge over the Mississippi at St. Louis, with its central span of 515 ft., and two side arches of 497 ft. each. This enormous structure, designed for railway as well as passenger traffic, is well in progress, under the superintendence of its engineer, Mr. James B. Eads. It will be remembered that we have described this work at great length in the sixth volume of "Engineering," and that on page 345, we published a large engraving showing its general design, as well as the details of its construction. Its total cost will be about £640,000.

The Quincy Bridge, although actually opened for traffic in 1868, may be included amongst the last year's bridge-work of the States. This is the longest bridge spanning the Mississippi, the river at the point of crossing being 3,250 ft. in width, the navigation channel, however, being only 800 or 900 ft. broad. The bridge is divided into seventeen spans, two of 250 ft., three of 200 ft., eleven of 137 ft., and one large draw span 360 ft. long, the girder of the latter being 36 ft. in depth. The piers of the fixed spans are all of masonry; that of the swing is formed of four wrought-iron cylinders 14 ft. in diameter, sunk through 50 ft. from the water level; upon the top of these a turntable, 30 ft. diameter, rests, and carries the span. The total cost of the work, designed and carried out by Mr. Thomas C. Clarke for the Quincy Railroad Bridge Company, was £215,000.

At Omaha, in the State of Iowa, four railway companies—the Union Pacific, the Chicago and North-Western, the Chicago and Burlington, and the Chicago and Rock Island—combined last year in the construction of a long bridge across the Missouri, designed by General G. M. Dodge, the Engineer of the Union Pacific Railroad. This bridge is 2,800 ft. in length, divided into 11 spans of 250 ft. each, resting upon concrete filled cast-iron cylinders 8 ft. 8 in. in diameter. Some of them require to be sunk to a depth of 70 ft. below low-water mark, making the total length of column 139 ft. The superstructure of this bridge is formed of ordinary wrought trussed girders, with cast-iron top member. In addition to the bridge itself, approaches three miles in length are also required, principally formed of trestle work.

Action has also been taken in the matter of the Cornwall Bridge, to cross the Hudson river, about 40 miles above New York city. The total length of this work, with approaches, will be 2,500 ft., the clear span 1,600 ft., the same as that of the East River bridge, and the height of the towers 280 ft. The platforms, railroad and passenger, would be carried by wire cables (70,300 miles of wire would be required), upon Mr. Roebling's system, and the estimate of the

whole work is £500,000. The main object attained by this bridge would be the transfer of the vast coal traffic of the Hudson river to the railway companies between Pennsylvania and the New England States.

Last January, a new bridge across the Niagara river, about half a mile below the Falls, was opened for general traffic. This work was erected by Mr. Samuel Keefer, for the Clifton Suspension Bridge Company, under two charters, one from the State of New York and one from Canada. The total authorized capital was $400,000.

This magnificent bridge spans the gorge of the Niagara river, where its depth is 180 ft., and its rocky sides rise up some 80 ft., to the level of the table land above. The span between the points of suspension is 1,268 ft. 4 in., and the deflection of the cables in the centre is 90 ft. The towers are 100 ft. in height, built of white pine, and disposed in pairs, each in the form of a truncated cone, 28 ft. square at the base, and 4 ft. square at the top. The towers are placed 13 ft. apart (in the clear) at the base, and they are braced together at intervals for their whole height. Two cables carry the platform over the towers, where they are 42 ft. apart, converging to 12 ft. apart at the centre of the bridge. Each cable is composed of 7 ropes, twisted from 7 strands, and every strand contains 19 wires, 155 in. in diameter. All the wires in the cables were drawn in one length, so that the cables are without splice or weld from end to end.

The platform is supported by a combination of diagonal and vertical rods; of the former there are 48 in all, reaching from the towers half way to the centre of the bridge. They are formed of wire rope varying in diameter from $4\frac{1}{4}$ to 3 in., according to their position. The vertical suspenders are also of wire rope $\frac{5}{8}$ of an inch diameter, and placed at intervals of 5 ft. There are altogether 480 of these, representing an aggregate strength of 4,800 tons. In addition to these supports, 54 guys are introduced to steady the platform, of these 28 are on the up-stream, and 26 on the down-stream side. These extend nearly to the centre of the bridge and are moored into the rocks on each side. The roadway is stiffened by a light wood and iron longitudinal truss, 6 ft. 6 in. deep, and going down 2 ft. 6 in. below the platform level. Transverse floor beams of pine, bolted together in pairs, and placed in groups at intervals of 5 ft., rest upon the longitudinal girders, and upon these is placed the flooring, formed of two thicknesses of pine $1\frac{1}{4}$ in. thick.

In Philadelphia, a new bridge across the Schuylkill has been set in hand, with two platforms, the one to remove the railway from the level of the streets through which it ran, to the infinite inconvenience of the street traffic, and the other to effect an improved communication between the large streets of the city. When completed, this bridge will have a clear span of 340 ft., a width of 50 ft., and a depth of truss of 35 ft. The work is being carried out by Mr. J. Linville, of Philadelphia.

On the New Haven, Middletown, and Willimantic Railroad, between New York and Boston, a bridge to span the Connecticut has been decided on. Its total length is 1,248 ft., and 2 of the spans will be formed to swing, with openings of 160 ft. each. The clear headway above the water is 42 ft., and the depth of the truss is 20 ft.

At the beginning of last year an important bridge over the Mississipi, at Dubuque, Iowa, was opened for the accomodation of the Union Pacific Railroad. Its total length is 1,760 ft., divided into 7 spans, the principal of which is a swing of 460 ft. long, and turning on a centre pier 20 ft. in width. This bridge was constructed by the Keystone Bridge Company, of Pittsburg, in less than 8 months.

Lastly, among American bridges of the past year, we may mention the great work across the Missouri river at Kansas City, designed and erected by Mr. O. Chanute, and representing one of the most successful examples of bridge construction in America. The total length of the bridge is 1,387 ft., divided into 7 spans, one of which is a draw span 363 ft. in length. Besides the bridge itself the approaches involved the construction of 2,360 ft. of trestle work viaduct. We have so recently described this work, that we need hardly refer to it again in any detail; it will be remembered that the great difficulties lay in the foundations, and that the rapid current, the impetuous floods, and the ever shifting bottom, brought about some failures, and necessitated an

almost unprecedented amount of skill and care on the part of the able engineer to whom this work was intrusted.

At home, with two notable exceptions, we have but little to show for the past year's work in bridge construction.

At Halifax, a cast-iron arched bridge, in 2 spans, by Mr. John Fraser, of Leeds, has been completed; the openings are each 160 ft., with a rise of 16 feet. The architectural effect of this bridge is good, and the spandrel filling and parapet well designed.

The two great metropolitan bridges have been finished this year—the Holborn Viaduct and Blackfriars Bridge.

At the Woolwich Arsenal, the pier designed by Mr. J. W. Grover, for the shipping and unshipping of guns, is in progress. This pier has a total length of 328 ft., divided into 6 spans of 48 ft. each. The width of the platform is 22 ft. 6 in., and the size of the pier-head is 40 by 50 ft. A 30 ton crane, resting upon a 7 ft. diameter cylinder, is placed at the end of the pier. The cost of this work will be £10,000.

The proposition for the widening of London Bridge has been seriously discussed during the past year, and many schemes have been submitted to the consideration of the Common Council. Of these we need only say that not one, which proposes to add considerably to the width of the platform, whether by cantilevers, or girders placed alongside the existing structure, at all fulfils the requirements of the case. It is not likely that any action would ever be taken to carry out alterations which would mar the bridge entirely; but it is an aditional security that the foundations of London Bridge have all their work to do in carrying the structure as it at present stands, and that any additional load could not be safely applied. Meanwhile attention is turned towards the practicability of making Southwark Bridge convenient for ordinary passenger transit, and by so doing to divert part of the London Bridge traffic.

A new bridge across the Thames at Wandsworth has recently been proposed, and will doubtless be decided upon. The design, however, has not yet been prepared.

Finally, we may refer to the Pons Asinorum, or Boutet's Bridge, designed to cross the Channel between Dover and Calais, in any number of spans desired, and comprising besides, the advantages of houses of refuge at the piers for shipwrecked mariners, and such like. This bridge, we need hardly remind our readers, is designed upon the novel and scientific principle, that if you stretch a single cable as far as it will possibly go without rupture, and then a little further, it will break; but if you put half a dozen such cables together, you obtain an infinitely strong foundation whereon to construct. But Boutet has not yet revealed the secret whereby he stretches cables, not only until they cease to sag, but have a considerable camber.

A New Safety Lamp.—It is half a century or thereabouts since the partisans of Sir Humphey Davy and of George Stephenson disputed as to who was the original inventor of the safety lamp; and during the period which has since elapsed, several alleged improvements, designed to increase its practical utility, have been produced. The most recent of these consists in securing the wire gauze or other casing of the lamp by means of a bolt, catch, pawl, or other similar fastening of iron or steel situated inside the lamp and held in its place by means of a spring. This bolt or catch, on the application of a magnet to the outside of the lamp, will be withdrawn by the attractive power of the magnet, so as to allow of the wire gauze or other casing being removed.

Jacketing Boilers.—One of the latest of the many plans proposed for preventing the radiation of heat from steam boilers consists in applying plaster of Paris by surrounding the vessel or surface to be protected in some cases, wholly or in part, by an envelope of sheet iron, lead, wood, or other suitable material, placing the envelope at a distance apart from the surface equal to the thickness required for the non-conducting material. The plaster of Paris is then made up in its liquid state and run or poured into the space between the envelope and surface of the vessel until the space is filled. The plaster of Paris in a few minutes solidifies without the application of heat, and the envelope may either remain permanently or be removed after the space is filled.

THE HAGAN PROCESS.

From "The American Exchange and Review."

Considerable effort has lately been made to draw attention to a process of disintegration of the gangue ores, particularly the gold-bearing quartz of California, by a process known as the Hagan process. We have gathered from various sources the following statements and descriptions:

This process sets up the claim that through its use practically the entire contents of any gold or silver-bearing ore can be saved and made available.

The method of treatment is as follows: The ore, as it comes from the vein, is broken to battery size before being put in the furnace; and it will be observed that this involves no expense which is not now incident to the common mill process, as all ores must be broken to proper size before being reduced in the battery. When broken as described, the ore is dumped into a furnace built of either stone or brick, whichever may be the cheapest in construction. This furnace is about 4 ft. in diameter of ore chamber, by about 20 ft. in height, a furnace of this size having the capacity of about 20 tons. By the decomposition of superheated steam, a supply of oxygen and hydrogen gases is obtained, and these gases are conducted to the chamber containing the ore, and being brought in contact with the raw ore, they immediately attack the sulphur, arsenic, antimony, or other base materials which may be in the ore and expel them completely, thus removing all obstacles to the amalgation of the precious metal; in short, making the gold that may be in the rock really free gold, which is then as susceptible of amalgamation as ravine gold. The simplest pan process is all that is needed to extract the gold from the ore thus treated, and *all* the gold in the ore is yielded up, the loss being only the inevitable mechanical loss which results from manipulation in the pans.

In the case of silver ores, it is necessary to chlorinize before amalgamation, of course; and it seems remarkable that two such inventions as this Hagan-furnace process and Kustel's chlorination process, the two together seeming to form a complete solution of the great and hitherto unsolved problem of how to work rebellious gold and silver ores, should be announced almost simultaneously.

Of course the practical value of this invention depends very much upon the cost of the process. Regarding this, we learn that so far as the furnace itself is concerned, it is not expensive in construction. In nearly every locality where needed, the materials may be found upon the ground. The points to be sought in the construction are strength and capacity. These may be obtained by the use of either stone or brick. In any ordinary locality a 20-ton furnace ought not to cost, complete, over £2,000; and a furnace of 50 tons' capacity can be bought for less, proportionally, than of smaller size; and the larger the furnace the less will be the expense of treatment of the ore, as the same number of men can attend to either a 20-ton or a 100-ton furnace.

The cost of treatment per ton will be from 50 cents to one dollar and a half, according as 20 or 100 tons are treated at one time. It will be seen, therefore, that even the lowest grades of ore may be profitably treated by this process, and this greatly enhances the value of the discovery.

But still further advantages are said to result. The ore when treated is left in such a friable condition that it is most easily reduced, and the capacity of the battery is more than doubled, so that a five-stamp mill will reduce more of the treated ore than a ten-stamp mill will of raw ore. This advantage will be duly appreciated by those who know the cost of mill machinery; and the benefits do not end here. Not only is the capacity of any mill doubled, but the wear and tear of both stamps and pans is greatly reduced in consequence of the more friable condition of the treated ore. Considering these advantages, it may truthfully be affirmed that there is no additional cost by this process over the common method of milling ores, the gained advantages more than compensating for the cost of the furnace treatment.

It is quite probable that this new method may produce a radical change in the machinery for crushing ores, and make it possible for us to avail ourselves of that most desirable of all forms of ore-crush-

ing, viz., dry-crushing. We only make the suggestion; but if such a thing were possible, the fact would be hailed with satisfaction by practical mill men, who now realize the extent of the loss of precious metal through the wasteful, but seemingly unavoidable, method of wet-crushing.

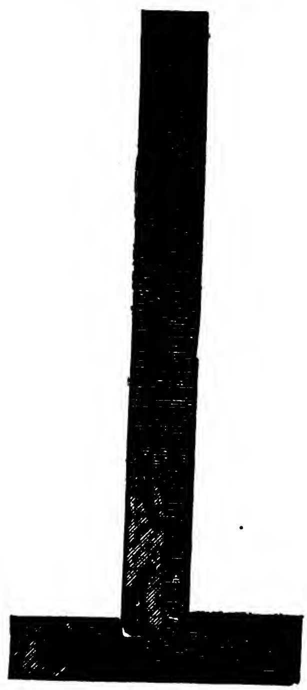
We will not now enlarge upon this matter, important as it is; but we have said enough to make it apparent that if what is affirmed of this process is true, we have cause for congratulating the public upon a discovery of such vast importance to the world at large. Coming at a time when the yield of the precious metals seems decreasing, and seeming to promise the unlocking of vast stores of hitherto unattainable mineral wealth at a moment when this wealth is most needed, this invention seems a blessing of almost infinite value, and we are sure our readers will unite with us in the wish that all that is claimed for it may be completely realized.

SOMERSET HOUSE ACCIDENT.

[From "Engineering."

The accident at Somerset House—if a catastrophe resulting from the operation of well-known and immutable laws of Nature can fairly be styled an accident—has fortunately afforded a few paragraphs only in the daily press. By good luck, the element of time was involved in the problem of probabilities in the present instance, and the fall of the girders, which was certain to occur sooner or later, took place at the most opportune moment; had the girders kept to their work but five hours longer, the resulting tragedy would have afforded a theme for many articles instead of receiving but the small publicity of a few casual paragraphs.

The whole history of the failure and its origin may be readily explained without diagrams, and with the aid of but few figures. The site of the accident is the east end of the river terrace of Somerset House, and the immediate cause of the same was the fracture of a cast-iron girder, by which an area of about 70 ft. by 25 ft. of the terrace floor was thrown upon and through the floor underneath. Three main girders resting upon piers projecting from the general face of the wall, by which the effective span was reduced from 25 ft. to 19 ft., divided the length of 70 ft. into four bays, and in each of these bays three cross girders, carrying two ring brick arches, with 1 ft. of gravel on the top, were joggled into the main girders, one cross girder occurring at the centre of the span, and the other two at distances of 3 ft. from the respective piers. It was at one of the latter points that the weakness of the structure was first evidenced; the fractured section there disclosed three terrible flaws, as shown on the accompanying cross section, the one on the outer edge of the bottom flange being no less than 11 in. deep. These



flaws were no doubt induced by the vicious form of the casting at the point where the cross girder was dovetailed into the main girder.

We propose in the first place to eliminate the factor of safety provided by the architect of the Somerset House terrace, assuming the castings to have been of

good quality throughout; we shall then ascertain how far the results will be modified by the flaws brought to light by the recent failure.

Referring to the sketch of the girder, it will be seen that at the point of fracture, the form of cross section is a ⊥, the vertical web being 1 ft. 6 in. $\times$ 1¾ in. about, and the bottom flange 7½ in. by 1⅝ in. average thickness. Between the cross girders a top flange 3½ in. wide is introduced, but of course this does not affect the strength of the girder as far as the present investigation is concerned. The calculated moment of resistance of the cross section (M) in feet $\times$ square inches is $M=10.8$ for compression, and $M=17$ for tension. It will, therefore, be necessary to deal with the tensile strains only. The dead load of the superstructure being 2 cwt. per sq. ft., it follows that the load upon the main girders, including the weight of the girders themselves, will resolve itself into 3 weights of 13 tons each —one at the centre of the 19 ft. span, and the others 3 ft. from each bearing. The moment, m, of the load at the latter points will of course be $m=19.5\times3=58.5$ foot tons, and at the centre an additional amount of $6.5\times6.5=42.25$ foot tons; hence, at the middle of the span, the point of maximum stress, $m=100.75$. Dividing m by M, we get the maximum *apparent* unit strain F, upon the metal, equal to 3.44 tons per sq. in. at points 3 ft. from the bearings of the girder, and to 5.93 tons per sq. in. at the centre of the span. Now the ultimate value of F in cast-iron girders of the form of cross section under consideration may be shown, upon the principles advanced in a previous paper (Strain on Beams, "Engineering," vol. v., p. 390), to be equal to 1.29 times the direct tensile resistance of the material; hence, estimating the latter resistance at the fair amount of 7 tons per sq. in., the ultimate apparent strength of the same iron in the girder form would be 9 tons per sq. in. This result is corroborated by two of Mr. Fairbairn's experiments on precisely similar forms of beams, in which the value of F averaged 9.1 tons per sq. in.

Adopting the preceding value, then, the factor of safety provided in the fractured girders would be 9 tons$\div$3.44 tons $=2.6$ at points 3 ft. from the supports, and $9\div5.93=1.5$ at the centre of the span —that is to say, even upon the false hypothesis of good iron and sound castings, the girders were loaded up to two-thirds of the breaking weight!

But, as the fracture did not occur at the centre of the girder, but at a point 3 ft. from the support, it is evident that the latter section was relatively the weaker, and it follows as a corollary that the flaws in the casting must have reduced its strength at least 45 per cent. There are no theoretical objections to this conclusion, for it was shown in the paper already cited that the loss of strength in a flat bottomed rail with a hole on one side of the flange amounted to one-third of the whole, although the loss of sectional area in the bottom member of the girder rail was less than one-sixth of the entire area of the metal in tension. There is nothing surprising, therefore, in finding a loss of 50 per cent. in strength accompanying the loss of 25 per cent. in the area of the bottom flange of the broken cast-iron girder.

The probable loss of strength, on account of the flaws actually measurable, being at least 50 per cent., it follows that the unit strain at the point of fracture could have been no less than 6.88 tons per sq. in., or in round numbers, ⅞ of the ultimate resistance of the iron. Now, Mr. Fairbairn found that a cast-iron bar would sustain a perfectly quiescent load, equal to 95 per cent. of the breaking weight, for some months, before failing, and that when the load was diminished to 75 per cent. the deflection continually increased during the five years of observation, and of course such a phenomenon clearly prognosticated the ultimate failure of the bar. There is nothing illogical, then, in the cast-iron beams of the Somerset House terrace sustaining a load equal to ⅞ of the breaking weight without any signs of weakness even had it been for half a century, and their final failure is but interesting confirmatory evidence of the previously ascertained fact, that, under such conditions, a grand crash must ultimately ensue. We do not know who designed the girders, and we are not sure that he is responsible for the accident. Possibly the imposition of 12 in. of gravel over the tiles covering the jack arches was not contemplated by the designer; if so, we can only hold him responsible for a working load equal to ⅓ of the breaking load; and in instances where dead load alone has to be sustained,

such a margin of strength is quite justifiable. Under the load actually imposed, however, the large dining-hall, 70 ft. by 25 ft., could only be compared to a Brobdignagian mouse-trap, and we care not to dwell upon the calamitous results which would have followed the coming down of the trap had it occurred at feeding time.

The simple facts of the case are, that the girders were carrying two-thirds of their calculated breaking weight, and probably would be carrying the same at the present time, had not the presence of some extensive flaws in one of the girders at a point 3 ft. from the support induced failure at that relatively little strained portion of the girder. The fall of one girder was of course followed by the destruction of the whole. We leave our architectural and building friends to draw their own conclusions.

BURNING POWDERED COAL.

From "The American Artisan."

In the breaking and screening of coal at the mines there is much dust and pulverized material made, for which, in this country at least, little or no use has been found. In England local accumulations of like character, at available points, have been disposed of in the fabrication of so-called "patent fuel," and a product similar to this, made by compressing the dust into blocks with some bituminous substance, has been for some time in use in the boiler furnaces of French steam vessels. With us the numerous projects for making a condensed fuel from the waste have met with little or no favor; possibly because the anthracite dust, to the utilization of which these plans have tended, is less useful for the purpose than that from bituminous coal, but principally because projectors have aimed to manufacture the artificial fuel from the dust collected at the mines, where the best grades of coal for burning can be sold at figures far less than the cost of making the compressed material. The success experienced abroad in making use of refuse, already brought to or near the place of consumption, is, therefore, no parallel to what might reasonably be expected to result from any attempt to make it in direct competition with the coal at the mouth of the pits. It being, therefore, doubtful whether artificial fuel can be profitably made on any extended scale with us, it behooves inventors to seek for some other means of utilizing the immense quantities of dust and refuse now lying useless wherever our great coal-fields are worked. There is good reason to suppose that this may be found in apparatus for burning powdered fuel, which could be obtained as well from the comminuted material adverted to as from that of the larger and usual commercial sizes. Our English exchanges speak of a furnace, of the construction of which we have no detailed description, by which, it is claimed, powdered fuel can be effectually and profitably burned. If in this country any efficient apparatus of the kind has been made, it has not come to our notice. Meanwhile the coal-refuse heaps grow broader and higher, and make more evident the truth that in them is the need of an invention which the boasted ingenuity of American projectors has thus far failed to provide.

Experiments, most of them made abroad, have shown that there are several essentials to any practical means of burning powdered fuel. Provision must be made for the regular supply of the material to the fire-box, and for the adjustment of such supply when desired. The powdered fuel must be very perfectly mingled with air previous to combustion. The arrangement of parts must be such that all resultant slag or cinder may be readily removed. Space must be afforded for the complete combustion of all the particles before the gases make their exit; and the whole construction must be such that no more than average skill and intelligence be required in its management and repair.

Although somewhat formidable in array, none of these requisites appear to be insurmountable. They could, in all probability, be overcome by suitable mechanical appliances, the cost of operating which would be slight in comparison with the advantages which would be gained by their successful application. Theoretically

considered, the uniform feeding of the material, which is mainly interfered with by its damp condition, would be insured by causing it to pass between rollers to a centrifugal distributer, by which the separation of its particles would be very thoroughly secured. From the distributer its passage to the fire-box could be aided by the direct action of an air-blast, which would insure the fulfilment of the second of the conditions previously adverted to. The others, matters more of mechanical judgment than of invention, could undoubtedly be provided for by simple means were the two former effectually met, either in the manner sketched or in a different one.

As to how far such theoretic ideas will apply in practice can, of course, only be found out by careful experiment. It is about time, moreover, in these days of high-priced fuel, that the refuse coal-dust be put to some useful purpose, the most obvious of which is, of course, the generation of steam, although there is no reason why it should not be employed as well in furnaces designed for other functions. It may be remarked, in conclusion, that it is somewhat surprising that so little has been even attempted in utilizing this refuse fuel. The engines of steam saw-mills are driven by the combustion of damp sawdust, fed regularly to the boiler furnaces by suitable agitating and feeding devices, and in tanneries the soaked tan-bark from the pits is burned in apparatus constructed for the purpose, effecting, even in small establishments, an annual saving of many hundreds of dollars. Success having been obtained with these materials, certainly not less refractory to combustion than coal-dust, there is good reason to suppose that the same result could be readily reached with the latter, were the same degree of attention expended upon it.

THE RESISTANCE OF VESSELS.

From "The Engineer."

At a meeting of the General Committee of the British Association, held at Norwich last year, it was resolved that a committee, consisting of Mr. C. W. Merrifield, F.R.S., Mr. G. P. Bidder, Captain Douglas Galton, F.R.S., Mr. F. Galton, F.R.S., Professor Rankine, F.R.S., and Mr. W. Froude, should be appointed to report on the state of existing knowledge on the Stability, Propulsion, and Sea-going Qualities of Ships, and as to the application which it may be desirable to make to Her Majesty's Government on these subjects. We now subjoin the first report which has been made by this committee, a report the value of which can scarcely be overrated.

FIRST REPORT.

Prepared for the Committee, by Mr C. W. Merrifield.

The subject referred to us is a very large one; and, having regard both to the space which a complete report on such a matter would require, and to the time at our disposal for making it, we have thought it best to lay before the present meeting a first report, in which we confine ourselves to the *resistance which ships offer to propulsion*, and to their *behavior in respect to rolling*. These are, in their several directions, the preliminary subjects necessary to the inquiry committed to us; and they are also the parts of naval science on which exact experiment appears to be most urgently needed, both for the direct knowledge of these branches, and also as a foundation for experiments on propulsion and the other applications which depend upon them. Knowledge of the work to be done should precede the selection of the tool with which it is to be performed.

RESISTANCE.

Total Resistance.—The question of resistance may be treated in two ways—either in gross, as regards the power required to drive a vessel of certain form and dimensions at a specified rate; or, in detail, as regards the exact way in which the vessel and the propeller act and react upon the water which they disturb. Hitherto there has been but little connection established between the phenomena of detail and the general result, the former not being understood with any reasonable degree of certainty, and the latter also being far from settled with precision.

The variable elements which go to make the resistance what it is, are chiefly velocity, form, condition of surface, and absolute dimension. The effect of form is as varied as the number of forms which can be given to a floating body. As regards dimension, assuming the forms to be diametrically the same, it has been found that vessels of different absolute size do not correspond in the degree of resistance which they encounter, whether in smooth water or in waves. It will also be seen that the absolute length of a ship, considered irrespectively of breadth or depth, has a direct influence on the resistance.

As regards velocity, it is usual to assume, in books on hydrodynamics, that the resistance of water varies as the square of the speed. For the purposes of naval architecture, this can only be taken to be roughly true under certain limiting conditions, beyond which the law of the squares deviates widely from the observed facts. It appears to be probable that this increase, as the square of the speed, is rather a minimum than a general rule of increase; and that such a minimum is only attained by ships of good form, and of a length which is a certain function of the speed. The vague words, *good form*, are used designedly; it being still uncertain what the best form may be, and what extent of deviation from it takes the vessel out of its operation. When the vessel is shorter than a certain limit of length depending on the velocity, the resistance seems to increase more rapidly than the square, and the power needed to drive the ship consequently increases faster than the cube of the velocity.

It may save confusion to remark that the measure of *resistance* is referred to a a unit of distance, while *power* is referred to a unit of time. For any law of resistance, therefore, the power varies as the product of the resistance and speed, and where the velocity varies, we have simply to use the corresponding integral formula.

As already remarked, the *leading formulæ* of the resistance to water are:

$$R \propto V^2, \; HP \propto R V \propto V^3,$$

the latter being the strictly necessary consequence of the former. There is but little disagreement among writers up to this point. But the moment we attempt either to assign values to the constants of the equations which they imply, or to introduce the corrections depending on the complex phenomena, which always, more or less, mask the mere question of fluid resistance, we find very little agreement.

The chief elements of the resistance of water to a body moving through it are:

1. The *direct head resistance*, due to the work of thrusting the water to the right or left, with or without vertical motion, in order to make way for the body to pass.

2. The *skin resistance*, or friction of the water on the surface of the moving body, combined with the effect of surface eddies and other minute phenomena.

3. The *back pressure*, due to the diminished pressure in rear of the moving body and in wake of any corners or unfairness of surface which may cause eddies.

4. In addition to these, there are the phenomena of capillarity and of the viscosity of water. These are of importance as regards minute bodies, including even small models. But for large ships, they are sufficiently accounted for in the arbitrary constant of skin resistance. This fourth head may, therefore, be neglected, except when we wish to pass from ships to models.

For extreme shapes it does not appear that the three leading elements of resistance can be grouped under one term. But there is reason to believe that, for vessels of a certain form, they all involve, with a respectable degree of approximation, the square of the velocity, and also that the forms for which this is true are among those which offer, *cæteris paribus*, the least resistance. Under these circumstances, the formulæ depending on skin resistance may be made to include the other two by merely altering the constants. We conjecture that, when authors state that certain elements of the resistance may practically be neglected, they usually mean that they can be accounted for in assigning the values to the arbitrary constants, which, in any case, must be determined from experiment. We have named vessels *of a certain form;* this form must be regarded as still unknown, except with reference to some limitations of a negative character, even these being rather indefinite. They include a fine entrance and a fine run, and an absolute length of not less than the length of the trochoidal wave moving with the same velocity. The

actual determination of the form of least resistance is not only unsolved, but the data of the problem are yet unknown.

The first formulæ that occur are the well-known coefficients of steam-ship performance :

$$\frac{(\text{Speed})^3 \times (\text{displacement})^{\frac{2}{3}}}{\text{Indicated horse power.}}$$

$$\frac{(\text{Speed})^3 \times \text{area of midship section}}{\text{Indicated horse power.}}$$

As affording a rough measure of comparison, the tabulation of these formulæ for different ships is extremely convenient. But they are of very little assistance in settling a theory. Even for the same vessel, tried under apparently similar conditions, these coefficients do not appear to be constant quantities. Moreover, the varying efficiency of the steam-engine and of the propeller, considered as machines for the transmission of power, are inseparably grouped with the work of overcoming resistance. When the consumption of coal is substituted for the I.HP., the efficiency of the furnace and boiler also comes in. Some of these remarks apply to Mr. Hawksley's approximate formula:

Velocity in statute miles=27.

$$27\left(\frac{\text{effective horse power}}{\text{wetted surface in }\square'}\right)^{\frac{1}{3}}.$$

But this was only intended for rough purposes.

We may here mention a formula given by Mr. Greene, in a paper read at the Franklin Institute of New York, and reprinted in the "Mechanics' Magazine" for 8th July, 1864. It proceeds on the assumption that the power expended in overcoming back pressure and friction in the engine varies directly as the speed:

$$\text{HP.} = D^{\frac{2}{3}}\,V\,(.1552 \times .0046846\,V^2),$$

the constants being obtained empirically.

Most modern formulæ for resistance take account of the form of the vessel, in such a manner as to require the use of the drawings of the exterior surface of the ship. The Swede, Chapman, in his well-known treatise on shipbuilding, assumes that the surface of the vessel may be divided into small portions, the resistance of each of which will be proportional to its area, to the sine squared of the inclination, and to the square of the velocity; with a certain small correction on account of the currents which are set up by the ship's own motion, and which modify the pressures. But he himself saw reason from subsequent experiments to doubt whether the law of the sine squared, or even that of the velocity squared, was applicable to the forms which he used.

Euler,* and most of the older writers use the sine squared of the inclination, as the factor representing the effect of obliquity; and this theory has been revived by Mr. Hawksley, in a discussion at the Institution of Civil Engineers, reported in their Proceedings for 1856, vol. xvi., p. 356. But we think that there is now ample experimental ground for believing that, whether or not this law be true with respect to an infinitesimal portion of a plane receiving the impact of a thin jet of water, it is not true either of plane surfaces of considerable extent, or, as a differential formula, of curved surfaces. It evidently fails to take account of the effect of the stream which is set up along the surface in deflecting the impact of water on the part of the surface further back from the entrance. The assumption that this has no effect is not one which can be admitted without proof; and the experimental evidence tends the other way. Chapman's later experiments, the experiments of the French Academy, and those of Colonel Beaufoy,† are all against the hypothesis of the sine squared of the inclination. The supposition that the sine squared of the inclination represents the effect of the obliquity of the after-body is still more open to doubt than when it is applied to the fore-body.

As a contribution to the history of the subject, the following translation from a tract of M. Dupuy de Lôme will be interesting:

Romme, in his Memoir for the Academy of Sciences, in 1784, while giving an account of the experiments made by him at Rochefort on models of ships, one of which represented a 74, and again, in his work on the "Art de la Marine," had very succinctly laid down that this resistance was

* See his "Scientia Navalis" (St. Petersburgh, 1749), vol. i., p. 213. See also D'Alembert, "Traité de l'Equilibre et du Mouvement des Fluides." Ed. of 1770, p. 226.

† See Chapman (by Inman), p. 257; Bossut, "Hydrodynamique," vol. ii., p. 396; Beaufoy, p. 87. See also Scott Russell's "Naval Architecture," p. 168; or "Proceedings of Civil Engineers," vol. xxiii., p. 346, as to the French experiments.

independent of form. "Provided," he went on to say, "the water-lines have a regular, fair curvature, as is the case in modern vessels, the greater or less fulness of the bow or stern neither increases nor diminishes the resistance of the water to their progress."

In direct contradiction to this too summary rule, which has long obstructed the progress of naval architecture, my experience leads to five principles, which I state as follows:

1st. Among vessels of similar geometrical form, of different size, but all having their immersed surface exceedingly smooth and driven at the same speed, the pressure needed to attain this speed increases more slowly than the surface of the greatest transverse section. It is near the truth to say, that, for similar forms, the resistance per square metre of midship section, at the same speed, decreases as the vessel increases, in the ratio of the square roots of the radii of curvature of its lines, these radii being themselves proportional to the linear dimensions of the ships; it is, therefore, wrong to compare the resistance of different ships by means of experiments made on models to reduced scales.*

2d. If the same vessel be driven at different speeds, the force needed to obtain these velocities increases less rapidly than the square of the speed, while that is small. The force increases as the square for ordinary rates of 3 to 5 metres per second, according to the condition of the surface in respect of smoothness. Beyond that speed, it increases faster than the square.†

3d. The diminution of the angle of entrance, and the lengthening of the radius of curvature of the lines which the water has to follow, especially in the replacement in wake of the stern by the water coming up from below, are the principal means of diminishing the resistance. This has the greater influence, the greater the driving power. For very slow motion, the influence of form is less than that of surface friction.

4th. The sharpness of the bow, both above and below the water line, which has in calm water the effect just mentioned, has more marked advantages in a heavy sea-way.

5th. The smoothness of the wetted surface plays a considerable part in the resistance; and this part, due to friction, varies but little with the speed.

I add that the resistance of the hull increases markedly in narrow channels, and still more where the depth of water does not much exceed the draught of the ship; so that experiments ought to be made in deep water.

Finally, my numerous observations on the resistance of ships, in calm weather and open sea, agree, with a close approach to exactness, with the following formula, which I have since adopted as the measure of the resistance:

$$R = K S (V^2 + 0.145 V^3) + K^1 S^1 (V)^{\frac{1}{3}}.$$

In this formula, I call—

S, the area of midship section in square inches.

S^1, the product of the mean girth (wetted) into the extreme length, also in square mètres.

V, the speed in mètres per second.

K, a coefficient varying with the form, diminishing inversely as the square root of the radii of curvature of the longitudinal sections, and also diminishing with the mean angle of entrance. This second reduction amounts to about 15 per cent., as the mean angle of entrance comes down from 45 deg. to 15 deg. It is, therefore, about one-half per cent. for each degree between those limits.

K^1, a coefficient independent of the form, and varying only with the smoothness of the wet skin. This coefficient can increase in the ratio of 1 to 10, from 0.3 for bottoms very smoothly covered with good copper, and the heads of the nails well beaten down, to 3.0 for hulls covered with weed and barnacles.

R is the resistance expressed in kilogrammes, and corresponding to the speed V.

For each ship experimented upon, two trials are sufficient to determine K and K^1.

For the Napoléon, while clean, the cop-

* M. Reech, Director of the "Ecole d'Application du Génie Maritime," has long since pointed out in his lectures the error frequently made of comparing the resistance of vessels of various forms by means of experiments upon models driven at the speed proper to the vessels themselves.

† I am here speaking of vessels only partially immersed, not of vessels which are entirely under water.

per being oxidized, not greased, I found

$$K = 1.96 \qquad K^1 = 0.44,$$

from which I obtain for the general expression for the resistance to the passage of the ship through the water:

$$R = 1.96\,S\,(V^2 + 0.145\,V^3) + 0.440\,S^1\,(V)^{\frac{1}{3}}.$$

A table previously given shows that during the trial trip of the Napoléon, the values of S and S^1 were:

S between 99 and 1000 square metrès.
S^1 between 1580 and 1610 square métres.

* * * *

The power needed to obtain this speed is obtained from this calculation by multiplying the resistance, so calculated, by the velocity.

The above remarks are translated from a Memoir published by M. Dupuy de Lôme on the occasion of his candidateship for the French Academy in 1865–6. It is reprinted in M. Flachat's "Navigation à Vapeur Transocéanienne," vol. i., p. 206.

It may not be out of place to mention, in explanation of M. Dupuy de Lôme's remarks about the angle of entrance, that the architects of the Imperial Navy avoid the use of the hollow bow. There is at most a slight concavity at the forefoot. Hence the angle of entrance has a meaning which is sometimes lost in modern English practice.

M. Bourgois, in his Memoir* on the "Resistance of Water," gives formulæ which may be grouped under the general form of

$$R = B^2 V^2 \left(K_1 + K_2 \frac{l V^2}{B^2} + K_3 \frac{S}{B^2 V}\right),$$

B^2 being the area of midship section, S the wet surface, and l the breadth extreme. K_1, K_2, and K_3 are constants which vary with different classes of vessels.

The dependence of the resistance of ships upon the theory of waves appears to have been first insisted upon by Mr. Scott Russell. That gentleman seems to have been the first to discover that there was a relation between the length of the ship and the velocity of advantageous propulsion, this relation being taken directly from the theories of the solitary and of the trochoidal waves. We will state his theory of resistance in as few words as possible:

Scott Russell's Theory of the Form of Least Resistance.

A vessel may be divided longitudinally into three portions, bow, straight middle body (if any), and after body. The midship section may be of any shape whatever, the resistance due to it depending on its area and wet girth only. The fore body must have for its level sections curves of sines (harmonic curves) whose equation may be written as

$$x = \frac{l\,\theta}{\pi},\; y = \tfrac{1}{2} b\,(1 + \cos.\ \theta),$$

b, being the half breadth of the ship at any level, and l the length of the fore body, which must not be less than the length of the "solitary wave," which has the same speed as the ship is intended to have, in order that the resistance may be the least possible. The after body is to have trochoids for its level lines, their equation being

$$x = \frac{l^1\,\theta}{\pi} + \tfrac{1}{2}\, b \sin \theta,\; y = \tfrac{1}{2}\, b\,(1 + \cos.\ \theta),$$

l^1 being the length of the after body, which is not to be less than that of one-half of the oscillating or trochoidal wave of the same speed as the ship. The straight middle body may be of any length whatever, as it will only affect the resistance by increasing the surface for friction; or, subject to these conditions, the resistance of the ship will be expressed by

$$(K \oplus + K^1\,S)\,V^2,$$

where $\oplus$ represents the area of midship section, and S the wetted surface. K and K^1 are coefficients, the former of which may be roughly stated at $\frac{1}{10}$ of that due to a flat plate drawn flatwise through the water, and the latter depending upon the condition of the surface. For a pure wedge bow, whose angle is ε, Mr. Scott Russell considers that the resistance varies as $\left(\frac{\pi}{2\pi - \varepsilon}\right)^2$—$\varepsilon$ lying between the limits of 12 deg. and 144 deg.; and where the bow is compounded of this and of the wave form, he gives as a rough measure of the resistance, a formula obtained by compounding this, in such proportion as may properly represent the geometrical combination of form, with the resistance due to the wave form.

* Published at Paris, by Arthur Bertrand. See also Sonnet, "Dictionnaire des Mathematiques Appliquées," Art. "Résistance des Fluides."

As far as can be judged by Mr. Scott Russell's published writings, there appears to be some unsettled ground in his theory relatively to the shape of the after body. The form of the bow is simply that of one-half the profile of a solitary wave of translation, laid horizontally instead of vertically. The form of the stern is also taken from the form of the wave, which is set up when a hollow in the surface of water has to be filled up; but it is nowhere made clear whether this form ought to be given to the level sections, or to the vertical longitudinal sections, or whether some compromise should be made between the two; and it seems probable that the author himself was doubtful on the subject. The experiments recently made under the direction of the Committee of the British Association appointed to make experiments on the difference between the resistance of water to floating and immersed bodies (Report for 1166, p. 148), seem to indicate that that doubt is still unsettled.

Without hazarding an opinion as to whether this form is really that of least resistance, it appears certain that the curves used are among those along which fluid particles can glide smoothly, without causing supernumerary diverging waves in the liquid.

The general formula for the length of a ship given by this theory is:

$$\text{Fore body in feet} = \frac{2\pi}{g} V^2 \text{ in feet per second.}$$

$$\text{After body} = \tfrac{2}{3} \text{ fore body.}$$

The following are the values of the factor and its logarithm, which give the length of the fore body in feet, when the velocity is given in

Feet per second....	0.19,518	log. = 9.29045.
Knots per hour	0. 5,561	log. = 9.74515.
Statute miles per hour................	0.41,985	log. = 9.62310.

Professor Rankine states, as the result of his own observation, that it is possible to shorten the bow to two-thirds of the length given by this formula, without materially increasing the resistance; but that it is very disadvantageous to shorten the after body.

In the "Proceedings of the Civil Engineers," vol. xxiii. (for 1864), p. 321, is a paper by Mr. G. H. Phipps, on the "Resistance of Bodies passing through the Water." Mr. Phipps considers that the total resistance may be subdivided as follows, into additive parts:

Head resistance—varying directly as the midship section, and inversely as the square of the projection ratio of the bow.

Stern resistance—a similar function for the stern.

Friction resistance—varying directly as the surface immersed.

Additional head resistance—an empirical correction assumed to be a function of the immersed surface, and of the draught of water.

The sum of these resistances is then multiplied by the square of the velocity.

The paper was followed by a discussion, in which most of the leading English writers on Fluid Resistance took part. The paper and discussion thus constitute a very fair *résumé* of the opinions then held on the subject in this country.

Mr. Phipps considers that the coefficient of friction of water on the outer surface of a vessel is less than on the inner surface of a pipe; and this is, to a certain extent, in accordance with the experiments of Darcy on the friction of water in pipes, which led to the conclusion that the coefficient of friction consists of two terms—one constant, and the other varying inversely as the diameter of the pipe.

Mr. John J. Thornycroft, C.E., in a paper read before the Institution of Naval Architects this year, and which will appear in their forthcoming volume of "Transactions," gives the following formula, the form of which is derived from experiments on the flow of water in pipes:

$$\text{I.HP.} = Vh \left\{ Sf \frac{3n}{2n+l} V^{1\cdot 7} + \phi\, \text{S.C.} \frac{n^{\frac{1}{3}}+3}{l^{\frac{1}{3}}+3} V^{2\cdot 7} \right\}$$

Where S = the wetted surface.
V = the velocity in knots.
l = length.

h, f, n, C, are constants empirically determined.
$$\begin{cases} \log.\ h = \bar{3}.65450 \\ \log.\ f = \bar{2}\ 10170 \\ \log.\ C = \bar{2}.0041 \\ n = 380 \end{cases}$$

$$\phi S = f (\sin \theta)^{2\cdot 5}\, ds,$$

ds representing an elementary portion of the surface, S, and θ the angle which this portion of the surface makes with the line of motion. It will be noticed that the formula involves a large number of constants, more or less arbitrarily determined.

Professor Rankine, in a paper in the "Transactions of the Institution of Naval

Architects" for 1864 (the substance of which is repeated in a treatise on "Shipbuilding: Theoretical and Practical"), states that the processes amongst the particles of water through which resistances to the ship's motion may be caused indirectly, may be thus enumerated:

1. The distortion of the particles of water.
2. The production of currents.
3. The production of waves.
4. The production of frictional eddies.

The first cause he regards as having no appreciable effect on actual ships, although possibly sensible in small models. Of the second cause (the production of currents), Professor Rankine remarks, that it "never acts upon a well-designed ship; for such a ship is so formed that the particles of water glide over her surface throughout its whole length, and are left behind her with no more motion than such as is unavoidably impressed upon them through adhesion and stiffness; and hence the failure of the earlier theories of the resistance of ships, which were founded on experiments made with flat plates, wedges, and blocks of *unfair* shapes.

Dr. Rankine then gives a detailed account of the waves which accompany a vessel driven at a speed greater than the limit to which she is properly adapted, showing that they diverge from the course of the vessel, at an angle depending on the proportion in which their speed of advance is less than her speed, and thus carry off energy, which is lost; and he proceeds to state: "The conclusion to be drawn from these principles is, that for each vessel there is a certain limit of speed, below which the resistance due to the production of waves is insensible; and that as soon as that limit is exceeded, that resistance begins to act, and increases at a very rapid rate with the excess of speed." "Through the discoveries of Mr. Scott Russell, a vessel can be designed in which this kind of resistance shall be insensible up to a given limit of speed; and therefore, the resistance due to waves has no sensible action on a well-formed ship." These remarks, of course, apply only to waves formed by the ship, and not to sea waves which she may have to encounter.

"The resistance due to frictional eddies thus remains alone to be considered. That resistance is a combination of the direct and indirect effects of the adhesion between the skin of the ship and the particles of water which glide over it; which adhesion, together with the stiffness of the water, occasions the productions of a vast number of small whirls or eddies, in the layer of water immediately adjoining the ship's surface." Instead of assuming that the frictional resistance is simply proportional to the actual immersed surface, Dr. Rankine uses what he calls the *augmented surface,* which is obtained by multiplying each infinitesimal element of the surface by the cube of the ratio which the velocity of the gliding of the water over that portion bears to the speed of the ship, and summing them. Let s be the actual surface, and q the velocity ratio of gliding; then the augmented surface is $\int q^3\, d\, s$; and if, further, V be the speed, g, gravity, w, the heaviness of water, and f, the coefficient of friction, then

$$\text{Eddy resistance} = \mathrm{V}^4 f \frac{w}{2g} \int q^2 d\, s.$$

Taking the cubic foot as the unit $\frac{w}{2g}$ does not differ much from unity for sea water, and the formula thus reduces to $\mathrm{V}^2 f \int q^3\, d\, s$.

It is, of course, impossible to calculate $\int q^3\, d\, s$ in detail for every ship; and it therefore becomes necessary to find some auxiliary formula. In the "Philosophical Transactions" for 1863, pp. 134–7, Mr. Rankine has shown that the augmented surface of a trochoidal riband on a given base and of given breadth may be found by multiplying their product by the following coefficient of augmentation:

$$1 + 4\,(\sin\phi)^2 + (\sin\phi)^4$$

in which ϕ is the angle which the inflexional tangent makes with the base. For a ship in which the stream-lines or tracks of the particles of water are trochoids, it would be a sufficient approximation to integrate—

$$\text{length} \times \tfrac{1}{2}\,\text{breadth} \times \{1 + 4\,(\sin\phi)^2 + (\sin\phi)^4\}$$

with regard to the draught of water, considering both the angle ϕ and the half breadths as variable elements to be determined from the drawings. Where the stream-lines are not trochoids, ϕ may be taken as the angle of greatest obliquity. But the theory has been only partially extended to three dimensions; and indeed, if it were possible to do so, the mere introduction of a third variable would not meet

the case unless account were taken of the vertical displacement of the surface of the water, consequent upon the uniformity of pressure at that surface.

The resistance determined by the calculation of the augmented surface includes in one quantity both the direct adhesive action of the water on the ship's skin, and the indirect action through increase of the pressure at the bow and diminution of the pressure at the stern.

For the coefficient of friction, Professor Rankine takes f=0.0036 for surfaces of clean painted iron. This is the constant part of the expression deduced by Prof. Weisbach from experiments on the flow of water in pipes. The corresponding coefficient deduced from Darcy's experiments is 0.004.

The augmented surface in square feet, multiplied by the cube of the speed in knots, and divided by the I.HP., gives *Rankine's coefficient of propulsion.* In good clean iron vessels, this ranges about 20,000; while in H. M. yacht, Victoria and Albert (copper sheathed), it reached 21,800. Its falling much below 20,000 is considered to indicate that there is some fault either in the ship, or in her engines or propeller; or else that the vessel is driven at a speed for which she is not adapted.

Professor Rankine adds, that "as for misshapen and ill-proportioned vessels, there does not exist any theory capable of giving their resistance by previous computation."

This again raises the question: What are *good* forms? According to Professor Rankine's theory, they are forms along which a particle of water can glide smoothly. Among these, as a particular case, Mr. Scott Russell's wave lines appear to be included. But these are by no means the only ones which satisfy the problem of smooth gliding, or of stream-lines. Another method of constructing curves fulfilling this condition has been given by Dr. Rankine in a series of papers published respectively in the "Philosophical Transactions" for 1863, p. 369, and in the "Philosophical Magazine" for October, 1864, and January, 1865. Elementary descriptions of this method are given in "The Engineer" of the 16th October, 1868, and in a treatise on "Shipbuilding: Theoretical and Practical." Their theory has not yet been carried very far, and when we have reference to three dimensions, it does not appear that any specific mathematical form is to be preferred in respect of its total resistance to a long, fine, fair ship, either drawn or modelled by eye, by a practised draughtsman or modeller.

A possible connection between the resistance of ships and their depths of immersion has been pointed out by Dr. Rankine in some papers published in the "Proceedings of the Royal Society" for 1868, p. 344; in the "Reports of the British Association" for 1868; in the "Transactions of the Institution of Naval Architects" for 1868; and in "The Engineer" of the 28th August, and 30th October, 1868. He shows from theory, corroborated by his own observations, and by those of Mr. John Inglis, Jr., that every ship is accompanied by waves, whose velocity of advance is $\sqrt{g k}$, g being gravity and k the *mean depth of immersion*, found by dividing the displacement by the area of water-section. So long as the speed does not exceed $\sqrt{g k}$, these waves cannot produce any additional resistance; but when the speed exceeds that limit, the waves are made to diverge from the ship at the angle whose cosine is $\frac{\sqrt{g k}}{\text{speed}}$, and thus to carry away energy, like the other diverging waves previously mentioned.

The form of the midship section does not appear to exercise any influence on the resistance to propulsion in still water, except so far as it affects the extent of wetted surface exposed to the action of the water. If the wet girth and the breadth at the water-line be given, the form of greatest area will be a segment of a circle; but this will not be the solution of the question which usually presents itself, namely, given the breadth and the draught required, the form for which the ratio of area to surface shall be the greatest possible. In the particular case in which the draught is half the breadth, it is easily seen that the ratio of area to girth is the same for a semicircular as for a rectangular section, and, therefore, that the solution lies between these extreme cases. It does not appear that the general problem has yet been solved, and, perhaps, as the really practical problem relates to the ship and not to the midship section, it is of secondary interest. A restricted solution

has been given by Mr. James Robert Napier, in a paper read before the Glasgow Philosophical Society, and reprinted in the "Mechanics' Magazine" for 24th April, 1863, vol. ix., page 311, and in "The Engineer" for 1st of May, 1863, vol. xv., page 245.

The best ratio for good propulsion of length to breadth and draught, even when it is assumed that the length exceeds Scott Russell's limits, is not yet known. This is not, perhaps, of practical importance, inasmuch as considerations of economy, capacity, and handiness, generally settle these proportions, without much reference to a theoretical maximum of efficient propulsion. But the extent to which an increase of breadth or depth, leaving other things unaltered, affects the propulsion itself, can hardly be regarded as within our settled knowledge.

The resistance of the air to a ship's hull is not a point to be neglected in practice or in experiment, but it is not one which we propose to discuss here.

The above contains an abstract of nearly all that is known concerning the *total resistance* of a ship in smooth and deep water. We do not consider it necessary in this report to enter into the question of the increased resistances due to shallow water, narrow channels, or a rough sea. We may sum up the result in the broad statement that there exists no generally recognized theory or rule for calculating the resistance of a ship. Many such rules have been put forth, but they do not agree in their form or in their result, and the credit of each consequently rests, as a practical matter, on the reputation of its author.

RESISTANCE CONSIDERED IN DETAIL.

It cannot be said that our knowledge of the detailed phenomena which accompany the motion of a floating body through the water, extends far below the surface of the liquid. Meanwhile the following things appear to be known.

For any vessel driven through the water by any power which does not react on the fluid, there must be a certain movement of the surrounding liquid, chiefly in the direction of the vessel's motion, which shall be sufficient to absorb the work done by the propelling force; for this is really nothing else than the work done by the power in overcoming the resistance. Much of this is masked by oscillatory movement. Now the setting up of an oscillation involves an expenditure of work; but the maintenance of the oscillation once established, is independent of the force which caused it, to just the same extent that it takes work to set a pendulum swinging, but once set going, the continuance does not depend on the starting force. It follows, that making a wave takes up propelling work; but that a wave once started maintains itself or dies out, as the case may be, independently of the propeller, which it can only affect by getting in its way.

In a vessel of good form thrust through a fluid, we first meet with a head pressure which relieves itself by the formation of a head swell, which disperses itself all round if time be allowed for it, either by the sharpness of the vessel's entrance, or by a slow rate of advance. This fixes a limit of speed, which cannot be advantageously exceeded, dependent on the length of entrance as well as on its form—on the length alone, if the form fulfil certain conditions. If the vessel be pushed beyond the speed of dispersion of this wave, it has to be pushed up hill, at a loss of useful work.

The frictional resistance of the surface of the ship also carries a stream of water in the sense of the ship's motion. In fact, nearly the whole work of friction is expended on producing this stream, which forms a part of the ship's wake.

The necessity of filling up the vacuum, which would otherwise be left in rear of the ship, also produces a following stream, accompanied with waves.

In vessels driven at a speed beyond what is suited to their form and dimensions, there are also supernumerary waves, an accunt of which will be found in Professor Rankine's writings, already referred to.

In vessels of unfair form there will further be violent eddies or whirlpools, as well as extra waves. Seeing that it takes an expenditure of work to make these, it is clear that least resistance means least disturbance. In reality, very little is known about these eddies. Their surface action has been observed, and may easily be seen in dirty water, with froth especially; but their extent in depth, and their amplitude as the depth increases, are utterly unknown; and the other phenomena are not sufficiently well understood to admit of

the effect of these being got at by exhaustion, that is to say, by being equated to the unexplained residue from the effects of the other known causes. Very little, again, is known about the direction in which the replacement aft takes place. The water may, of course, pour in either laterally or from behind, or it may well up from underneath as a wave, more or less; it probably does all three, and the proportion in which it does each is among the things which neither experiment nor theory has yet revealed.

Theoretically, it is of no importance whether we consider the ship in motion and the water at rest, or the ship at rest and the water in motion in an opposite direction. Practically, the conditions are modified by the consideration that a stream of water almost always has a sloping surface, in which case a resolved part of gravity is one of the active forces. Besides this, streams useful for experiment are restricted in depth and width, and the conditions of narrow and shallow channels introduce foreign considerations of a very complicate character.

PROPULSION.

We do not consider advisable in the present report to enter into the question of propellers, except so far as may be necessary to the choice of experiments.

All propellers except sails, tow ropes, and punt poles, do their work by the reaction arising from their driving a stream of water in the opposite direction to the ship's motion, or to their stopping or reversing streams already flowing in that direction. This is the case with oars, paddle wheels, screws, and water jets alike. But, while they thus have one principal action in common, they are only different in their detailed effect upon the currents and waves which accompany the ship, and in the way in which these currents and waves react upon them. Thus, the oars of a row boat send two streams aft, at such a distance from the sides of the boat as to interfere very little with, and to be very little interfered with by, the waves and eddies due to the boat's motion. In the screw propeller, on the other hand, a large proportion of the wake current is either stopped or reversed by the action of the screw, which also interferes with, and is itself reacted upon by, the wave of replacement. These differences are so large in amount as not unfrequently to mask the whole of the *slip*, from the reaction of which the propulsion is obtained, giving rise to the phenomenon of *apparent negative slip*. For a theoretical account of what is supposed to take place under these circumstances, we refer to the following papers in the "Transactions of the Institution of Naval Architects," and the discussions which took place upon them:

Rankine—"On the Mechanical Principles of the Action of Propellers."

Froude—Note on the above paper, vol. vi. for 1865, p. 13, *et seq.*

Reed—"On cases of Apparent Negative Slip," vol. vii. for 1866, p. 114, *et seq.*

Rankine—"On Apparent Negative Slip."

Froude—On the same.

Rigg—"On the Relations of the Screw to its Reverse Currents." vol. viii. for 1867, p. 68, *et seq.*

Rigg—"On the Reverse Currents and Slip of Screw Propellers." vol. ix. for 1868, p. 184.

See also Bourne—"On the Screw Propeller," second edition, chapter iii., and Rankine—"Shipbuilding: Theoretical and Practical," pp. 88, 89, and pp. 247, 259.

We consider it to be beyond doubt that the theoretical investigations of this part of the subject have been extended in advance of the point at which fresh experimental foundations ought to be laid for them.

FORMER EXPERIMENTS ON RESISTANCE.

The first important experiments were those made by Bossut, Condorcet, and D'Alembert, by direction of Turgot. The results were published as a separate work in 1777, and a very full abstract of them is given by Bossut in his "Hydrodynamique." The chief results are summarized by Bossut as follows:

That the resistance of the same body at different speeds, whatever be its shape, varies very nearly as the square of the speed.

That the direct head resistance of a plane surface is sensibly proportional, at the same speed, to the area of the surface.

That the measure of the direct resistance of a plane surface is the weight of a fluid column which has that surface for

its base, and whose height is that due to the velocity.

That the resistance to oblique motion, other things being alike, does not diminish by a law at all approaching that of the squares of the sines of angles of incidence, so that for sharp entrances, at least, the former theory must be completely abandoned.

Mr. Scott Russell has remarked that between certain limits the observed resistances of wedge bows could be represented with a close degree of approximation, by a formula of the form,

$$R=K\left(\frac{\pi}{2\pi-\varepsilon}\right)^2,$$

where K is a constant, π stands for 180 degs., and ε is the angle of the wedge, which is supposed to be of not less than 12 degs., and not more than 144 degs. See his "Naval Architecture," page 168, and "Transactions of the Institution of Civil Engineers," vol. xxiii., page 346.

The next experiments of importance are those of De Chapman, published in his "Architectura Navalis Mercatoria." The result of those has already been mentioned. He performed some fresh experiments at Carlscrona, in 1795, which seemed to lead to somewhat different conclusions. See Inman's Translation of De Chapman, page 41 and page 257.

We then come to Beaufoy's experiments in the Greenland Dock from 1794–1798. This enormous serious of experiments can only be regarded as establishing very few facts, among which we may mention:

That the resistance to oblique surfaces does not vary as the sine squared of the angle of incidence.

That for *unfair* bodies, such as he experimented upon, the resistance increases faster than the square of the velocity.

That increase of length, within certain limits, has a tendency to decrease resistance.

That friction of the wetted surface enters largely into the resistance.

That friction of the wetted surface appeared to increase in a ratio somewhat less than that of the velocity squared—between $v^{1\cdot7}$ and $v^{1\cdot8}$.

He also arrived at the conclusion that bodies immersed to a depth of 6 ft. experience less resistance than at the surface, but in the case of an iron plane towed flatwise, he found that the resistance increased with the depression.

The whole of these experiments lose much of their value from having been tried on small models, and on bodies which are not ship-shape.

The "Philosophical Transactions" for 1828 contain an account of experiments performed by Mr. James Walker in the East India Import Dock. A bluff bowed boat was towed across the dock by a rope and winch, worked by laborers, the rope being fast to a spring weighing machine on board the boat. The boats tried were of somewhat bluff form, and it was found that the resistance varied only roughly as the velocity squared, increasing faster than that at high speeds. The drawings of the boats are not given with all the detail that could be desired, nor is the condition of their surface minutely described. But the experiment was in the right direction, being upon actual boats meant for use, and of a size far exceeding the models of previous experimenters.

Some experiments by Mr. Colthurst both on the forms of floating bodies as affecting their resistance to motion, and on the friction of wetted surfaces, are given at p. 339 of vol. xxiii., of the "Institution of Civil Engineers' Transactions."

We also refer to the Report of the Committee appointed by the British Association, upon the comparative resistance of bodies wholly and partially immersed (B. A. Reports, vol. for 1866, p. 148). That Committee decided to print the observed facts without any deductions. It is not necessary to the purposes of this Report that we should discuss them. We have already alluded to the difficulty which they indicate as being felt, with respect to the way in which the water of replacement flows in at the stern.

We will next refer to the experiments of Captain Bourgois, which were begun at Indret, in 1844. He first had several boats from 22 to 25 ft. long towed by the Pelican steamer, then under his orders, and later a small merchant schooner of a little over 60 ft. long—and afterwards the Fabert, a brig 98 ft. long. These vessels were simply towed, and their actual resistances measured with a traction dynamometer. Similar experiments have also been tried in France with the screw steamer Sphinx,

109 ft. long; with the screw despatch boat Marceau, 131 ft. long (with its screw on deck), and with the 74-gun ship Duperré, 180 ft. long, built by Sané. Probably, nothing could be better than the experiments thus made, and it is from these that M. Bourgois has derived the coefficients of the formulæ which he has given. But, unfortunately, the particulars of the ships experimented upon are not given in great detail, nor are their drawings published. The only particulars given are the length and breadth on the water-line, the draught, and the area of midship section immersed; but without wet surface, or even displacement.

M. Bourgois's memoir has no date; but it is evidently later than 1843, since he mentions that as the date of an experiment. It also contains some results of trials of propellers set to work against a dynamometer with the vessel made fast, and some trials depending upon the measurement of the power exerted by the engine. But we do not propose to discuss the trials on steam-ship performance. Not only is this the work of another committee, but, inasmuch as they introduce the uncertain effects of the engine and propeller, they fail to give any accurate account of the resistance of the water.

In the earlier history of the subject, it was supposed that models would most aptly represent ships at the same speed both for the ship and the model. The experiments at the East India Import Dock, in 1827 or 1828, seem to show a dissatisfaction with the results of small models, and some time later, M. Réech, the Director of the Ecole d'Application du Génie Maritime in France, pointed out that models of different sizes, intended for comparison, should be made to move at velocities varying as the square roots of their lineal dimensions. In this case the actual resistances would vary as the cube of the lineal dimensions. This would follow from the theory of the resistance of submerged bodies, on the supposition that the resistance varies as the square of the speed. If, again, we consider Mr. Scott Russell's theory of the length of ships—that their extreme speed should not exceed that of an oscillating wave, bearing a definite ratio of length to that of the ship, we arrive at the same conclusion, the length of the wave varying as the velocity squared.

PROPOSED EXPERIMENTS.

The experiments upon resistance which we consider most important to be made are these:

That a ship of considerable size and fine form should be carefully selected; a screw steam-ship, with a screw capable of being lifted; with a clear deck, offering no unnecessary resistance to the air; and with little or no rigging.

That her form should be carefully measured in dock (her lines taken off, as it is technically called), and sight marks carefully laid down, so as to ascertain whether she deforms in any way when afloat.

That she should be towed at various speeds, from the slowest that can be rated to the fastest that can be obtained; and that the resistance should be ascertained by a traction dynamometer, self-recording.

That the place selected for the experiments should be a deep inland water, free from ground-swell, and such that the speed of the ship can be observed from the land as well as from the vessel. The water also should be clear enough to admit of being seen through to a considerable depth. The place, if tidal at all, should be free from cross tides or irregular currents. These conditions, it is believed, may be found both in Norway and on the west coast of Scotland.

Careful observations should also be made with a view to ascertain the direction and velocity of the local currents caused by the ship's motion. What these should be will demand careful consideration, having regard both to the ship and to the place selected, and to the *personnel* of the observers.

The same remarks will apply to the precautions necessary to prevent interference by the currents thrown back by the towing vessel or vessels, and to eliminate other sources of error. It is of especial importance that the ship which is being towed should be kept clear of the wake of the towing vessel or vessels. It might be necessary for this purpose to have two tug-boats with hawsers meeting at an angle in the form of letter Y.

It is desirable that these experiments should be performed with at least two vessels considerably differing both in size and in proportions, and, for each of them, with different conditions as regards smoothness of surface.

A third class of experiments should also be made to determine the rate of retardation of a vessel which has been made to attain a certain velocity, and then (the propelling power suddenly ceasing to act upon her) is allowed to come gradually to rest through the resistance of the water.

It would be desirable that the same vessels (and as nearly as possible under similar conditions of draught and trim) should be made use of for trials of propulsion, and that in these again a dynamometer should be interposed between the engine and the propeller, and that in this case also the local currents and waves due to the joint disturbance of ship and propeller should be observed.

We consider that experiments of the kinds which we have proposed have now become necessary, not only to the theory of resistance, but also to the practical calculations of the effect of steering and propelling apparatus, and incidentally to the design of these, and to the apportionment of engine power and driving speed.

Such experiments are quite beyond the means of anybody but the Government of a naval power in time of peace, possessing ships which must be exercised with their crews and staff of officers. There would of course be extra expense attending such trials; but this expense is in no way commensurate to that of building experimental vessels, or arriving tentatively at the suitable forms and positions for propellers.

We therefore recommend that the Council of the British Association should authorize a deputation to apply to the Admiralty to provide for such a set of experiments in the course of the summer of 1870; also that the Council should appoint a committee consisting of three members of the Association, to confer with officers of the Admiralty respecting the details of the experiments, and that the Admiralty should be requested to give an opportunity to the members of that committee of taking a share in the observations, in order that they may be enabled to make an independent report upon the results.

[TO BE CONTINUED.]

THE BLACK FOREST RAILWAY.

From the "Pittsburgh Evening Chronicle."

The following is an extract from a letter of C. Ackenheil, C. E., of Pittsburgh, describing the Black Forest Railway now in course of construction in the Grand Duchy of Baden, Germany:

About 30 miles of road brings the traveller to the foot of the heavy grade, at Hornberg. This little town is one of the most industrious places in the Black Forest, celebrated for its manufacture of clocks and musical works. In nearly every house parts of watches and clocks are made. The scenery there has great resemblance to that of the "Cumberland Narrows," Maryland. An old castle, built on a conspicuous rock, gives the place a very romantic look. 180 ft. above the town is the railroad station, 1,287 ft. above sea level; the railroad summit is 3,030 ft. One of the main tributaries of the Danube has its sources here. By tunnelling the summit, this height has been reduced to 2,780 ft.; therefore the whole rise between the beginning of the road and its highest point is 1,493 ft. The air line between these two points being only 7 miles, that gives for every mile of this line 213 ft. elevation. It was a hard task for the engineers to establish a line with a suitable grade, bringing in account the adverse influence of climate. The winter in those mountains is very severe, subjecting the road to heavy snow-drifts. However, by the most careful study of the ground; by the most skilful supervision of the surveys of Robert Gerwig, Chief Engineer, one of the ablest engineers in Europe; by investigating almost every inch of the topographical features, the engineers succeeded in establishing, after several years' work, a line answering, in the highest degree, every requirement in location, grade, and all other features of a first class railroad.

It was stipulated that the grade should not exceed 2 ft. per 100, or 105 ft. per mile; no radius should be less than 1,000 ft., a 5 deg. and 45 min. curve—rules which have been strictly followed. The air line of 7 miles was lengthened into 15¼ miles

by entering in side valleys; by going for instance on the north side of the main valley and returning for two miles on the south side; then making a turn again towards the north; higher and higher on the sides of the mountains the road climbs to the summit, in numberless bends. One tunnel follows another in quick succession. About half way, looking down into the valley, you are at least 600 ft. above its level; 200 ft. below you—nearly perpendicular—you see the railroad; 200 ft. further you see the road again, and at last, over 200 ft. further, you see the waves of the creek like a small silver thread between the rocks. From Hornberg to the summit there are 29 tunnels, the total length of which is 28,500 ft. The longest is the "Summit" or "Sommerau" tunnel, 5,600 ft. long; the next is the "Gremmelsbach" tunnel, 2,900 ft. long. The most remarkable was the "Triberg," so called "S" tunnel, 2,700 ft. long, having the shape of an "S," the most difficult work for construction on the whole road, because no shaft could be used. The heading of this tunnel was completed last November, after three years' work. The lengths of the other tunnels vary from 500 to 2,400 ft. One viaduct is to be constructed about 800 ft. long and 80 ft. high, all of cut stone. The geological formation is entirely granitic, which renders tunnelling a very hard and tedious work. The construction of the road was commenced in 1867, and is rapidly progressing; on the average they do from two to three feet of tunnelling on one heading in twenty-four hours.

The road will be finished 1873, and will be one of the greatest works of engineering in Europe. The cost of these 15 miles is about $5,000,000, and must be considered very high, the wages for labor being very low, from 60 cts. to $1 a day. Only nitro-glycerine, mixed with sand, is used for blasting; it has been proved the most effective material, and if worked with care it is not at all dangerous—not more than common powder. The track will be of steel rails, which are now adopted in Europe on all important railroads.

THE MARQUETTE MINING REGION.

BY MAJOR T. BROOKS.

Abstract of a paper on the Geological structure and working of the deposits of the Marquette District. (See Frontispiece.)

The best method of extracting a deposit of ore will necessarily vary with the nature of the ore, its geological structure and topographical position. No one, we think, can doubt the policy of having begun work at many of the openings of our iron mines by quarrying, which may be defined as mining in open excavations.

Having a large mass of pure ore before us, of unknown form and size, and covered by but a small amount of earth, it would certainly be folly to incur the delay and cost incident to sinking and drifting, to open ground thus already opened by nature and ready for us to win.

Our ore deposits are, as it is the design of this paper to prove strata beds, instead of veins; their extension, like coal beds, is laterally and not vertically; hence, stripping or uncovering, when it is not too heavy and expensive, is the true method of working.

When the earth or rock covering becomes heavy, and treacherous hanging walls loom threateningly over our heads, should we attempt to work the deposit as an open cut, we may as well pause, and ask whether the centuries of experience by miners in other districts and other countries, under circumstances similar, and, perhaps, sometimes more difficult than ours, may not have pointed out some more practicable, permanent, and economical method of extracting ores, than the very obvious and simple one of quarrying.

Which one, if any, of the well-tried systems of mining that have been wrought out and perfected elsewhere, can be advantageously applied to Lake Superior iron mining, is a pregnant question at this period in the history of our iron industry, and one that should soon be answered at all our mines.

In the time that is coming those mines which have been opened, and are now

being worked as quarries, will soon have to make many changes in their system of working, their traditions, organization and labor. The common laborer with his pick and shovel, horse and cart, barrow and derrick, will play a far less important part. In their place will be found the skilled miner, steam-engines, nitro-glycerine (perhaps) and the tallow dip. Mining engineers, mining captains, and timbermen will be found in the staff of the mine. Then our mines will continue in a long career of prosperity, which may be interrupted by irregular or unwise tariff legislation, but which can only be terminated by the exhaustion of the beds, which must sooner or later come. The critical period for each mine is the transition from the old to the new system; to stop quarrying and begin mining in time to make no interruption in the supply of ore. It would be a very serious drawback for any mine to be able to supply only one-half its regular customers for a season or two, especially if there happened to be active competition. This danger is plainly pointed to by the disaster last fall at the New England slate ore opening. The hanging wall of talcose schist fell in, destroying a large amount of timber work, and completely stopping mine work for a long time. A large expenditure of time and money will be required before the mine can be again made productive. This danger is increased by the fact, that reserves of ore from which to draw during times of low product, are unknown in the district. We "pick out the eyes of our mines," to use a Cornish expression, at the close of every shipping season.

Probably the most important preliminary question connected wito the adoption and putting in practice of a permanent regular system of mining, aud the construction of the necessary works which are to affect the whole future of the mine, and determine to a great extent the amount of its profits, is that of the geological structure of the ore deposits themselves. Certainly, to extract a mass of hidden ore advantageously, the more we know of its position, form, size, direction and dip, and the better our acquaintance with the nature of the associated rocks, particularly of the hanging wall, the better we can plan and execute our attack on such ore mass—the better we can locate our permanent machinery and shafts, our tunnels, pockets, dumps, tracks and roads, waste and stock piles, and place the necessary houses.

I may here properly quote a portion of a letter from Warrington W. Smythe, Crown Inspector of Mines in Great Britain. I sent him a rough sketch, giving an approximate section of the Lake Superior mine similar to the one presented, and asked him to name some book which treated of a similar case. He very kindly replied in a private letter, from which I venture to make the following extract:

"* * * We have no English books which deal with the problem you have set before me; nor have we, indeed, any case analogous to that of the very remarkable orey bed which you describe. The only work which we have in Europe dealing pretty fully with the working of deposits of various thicknesses and position, is that of M. Ponson, a Belgian, on Coal Mining, published at Liege, in three octavo volumes, with a folio of plates. In this you would see how the Belgium coals get into a position alternately flat and highly inclined, and have to be worked in the two cases by different methods. But then these seams are thin, and offer smaller difficulties. Your district will have, I suspect, to follow out the plan which the French are doing very largely in some of their coal mines, where the beds are from thirty to ninety feet thick, but broken and turned up usually at high angles. This is the mode of working, as they call it, by *remblais*, or filling up as they go on, with loose stuff—clay, coal-measure, shale, grits, etc.,—taken down for the purpose, often through special shafts and drifts, so as not to interfere with those devoted to coal raising."

If the above general view of the question be correct, then it is evident that all sources of information as to the details of geological structure should be exhausted before a plan is made and underground work begun; and then, on the uncertainties which are inherent to the question, our system should be so devised as to have sufficient elasticity, so to speak, to meet probable unknown conditions which the progress of mining may develop. Fortunately, the vast excavations now open to daylight at our several mines present a fine opportunity to study the gen-

eral structure. The details are in many cases obscure, the quarrying process having removed and deposited in stock or waste piles material which showed many curious geological phenomena, and which could have been studied to advantage.

The first and by far the most important inquiry in this study of geological structure, and the one to which the remainder of this paper will principally relate, is this: Do our Marquette iron ores occur in beds or veins; that is, are they highly metamorphosed and disturbed aqueous deposits, which were laid down at the same time as the associated rocks, or have they been since formed?—in which case they must be either volcanic dykes, or else fissures or segregated veins.

This question is not presented as a purely scientific one, because as a theoretical question among geologists it has been settled. But it is presented as a practical one, bearing directly on the economic extraction of iron ores—and as a question on which those engaged in the direction, management, and working of our mines widely differ.

If our deposits or any of them are true veins, then the regular system of vein mining which is finely exemplified in the Lake Superior copper district, covers the case; except that in some instances our deposits, being of unusual thickness, may require some modifications in the system. If, on the other hand, our ores constitute strata beds, conformable with the rocks with which they are asssociated, then we have a structure entirely different, and requiring a different mode of procedure, and in this case should look for our models to the very thick coal beds of France, or perhaps better to those of Belgium, as as being more contorted, folded, and disturbed—hence, more closely resembling, in their irregularities of dip and thickness, the highly metamorphosed schists of this district. At present several of our mines are directed and managed in the full belief that the ore deposits are either true veins, or at least have such essential qualities of veins that they may safely and advantageously be wrought as such. In some instances, the mine superintendents are full believers in the bedding theory of formation. Probably in most cases there is no settled belief on the subject, nor much faith in the advantage of such knowledge; but in place of any such doubt, a feeling of certainty to the effect that geologists are dangerous dreamers, and that the Lake Superior iron mines present inexplicable phenomena, such as were never before seen in the earth, and such as geology will never explain, nor find duplicated elsewhere. Lake Superior iron ores being almost exceptionable in richness, so they would naturally be in structure.

In the hope of presenting a full logical proof on this question, to the few who are in doubt, I shall, even at the risk of being tedious, cite those definitions and characteristics of veins which are taught and accepted by the best authorities, together with the characteristic phenomena of our ore beds, thereby hoping to prove that they cannot be rated as veins or igneous deposits, but, on the contrary, are true aqueous beds, or rock layers.

(A.) A true vein is a fissure or crack in the solid crust of the earth, of indefinite length and depth, filled with some metallic ore or mineral substance, different from the containing rock. Veins, in most instances, extend across the lines of stratification of the formation in which they lie. In the rare instances in which they conform with the bedding, such coincidence is not for any considerable distance.

Now, if we look among the beds of magnetic and specular hematite ores of Lake Superior, Missouri, New York, New Jersey, and, I feel safe in adding, Sweden, we shall find them conforming exactly with the stratification of the containing rock, and in no instance crossing it, as veins almost invariably do. (It should be here remarked, that, owing to the great metamorphic and dynamic action to which the formations under consideration have been subjected, the bedding is often obscure and sometimes entirely hidden.)

(B.) Veins are usually in groups, parallel in course, or strike and dip.

Beds of iron ore, if several in number and regularly folded, present similar phenomena on the surface, as is seen at the Mt. Hope mines, and others in New Jersey. It is safe, however, to say that the Lake Superior ores never present this appearance. The fact that there is a general east and west parallelism is not to the point, for at the Jackson, Cleveland,

Lake Superior, and Washington mines there are dips in the same bed to every point of the compass, and from vertical to horizontal within a very small area.

(C.) Veins very seldom underlie at a less angle than 45 deg. with the horizon, and, as a rule, are much nearer the vertical. Their prevailing direction is downward toward the centre of the earth.

On the other hand, our iron ores are often horizontal and seldom vertical. The many folded beds which are plain to be seen at Lake Superior mines (see sketch giving a section of the Lake Superior mine), and undoubtedly exist at the other mines, must contain parts that are horizontal at the bottom and top of each alternating fold.

(D.) Veins generally run straight, both on the surface in their out-crop and downward; that is, their boundaries are more or less regular inclined planes. If the vein changes its course from a fault or throw, it will usually be found at no great distance, taking its first direction. This is as far removed as possible from the fact in the case of our iron ores, as is perfectly illustrated in the accompanying section above referred to.

This comparison might be continued to the exhaustion of all vein phenomena, with results as above. We might point out that the mineral constituents of veins —quartz, calc spar, fluor spar, heavy spar, and other minerals, not only are not characteristic of our iron ore beds, but, except the first, are wanting. Instead, we find in our iron mines, large beds of talcose and chloritic schists which are found in veins. Quartz is found universally associated with our iron ores, as it is in veins, but not having the same form. In the specular hematite mines, it is in thin beds interlaminated with corresponding thin beds of rich ore, or is in fragments forming a conglomerate. In the lower horizons or flag-ores, the quartz is so intimately mixed with the oxide of iron as to produce a homogeneous lean ore.

Again, the gossin, or decomposed vein matter which almost universally caps true veins, finds no counterpart in our veins. On the contrary, no perceptible change in richness, or in the mechanical condition of the ore, has been observed between the surface and lowest point yet reached in the district, say two hundred feet.

Experienced vein miners will not consider this comparison complete if I do not refer to the change in the character of the mineral contents of true veins, due to the passage of the lode from one kind of rock to another. Certain rocks are known to produce rich bunches in the lode, while other rocks give comparatively barren ground.

Nothing allied to this phenomenon has been observed in iron ores of the character we are discussing.

If the above be accepted as accurately describing a fissure vein, and as presenting correctly some of the characteristic geological phenomena of our deposits of iron ore, then the latter not only are not veins, but, on the contrary, are so unlike them that it would be unsafe to apply any of the principles, practices, or terms of vein mining to our case, without a careful consideration of the subject, else much confusion, uncertainty, and perhaps loss may ensue. This is a practical point of much importance, because many of our miners and experts, having got their experience in vein mining in other regions, are slow to modify their traditions and methods to suit the very different case presented here.

It would be still easier to prove that our deposits are not dykes or fissures, which are supposed to have been filled by volcanic agency. Any person in the district can satisfy himself on this point by an examination of a trap dyke pointed out by Mr. Breitung in the Washington mine. Neither can they be segregated veins, as could be proven. We are left the hypothesis with which we set out, and which completely embraces all of the facts adduced; that is, that the ores in question are simply strata beds or rock layers; having the same general form, origin, and structure as the layers of chloritic and talcose schist, the quartzites and diorites, with which the ores asssociated.

A simple view of the question is to regard oxide of iron as one of the half-dozen minerals which were chiefly used by the Great Architect in building our Huronian formation. Put our iron ore on the same footing as quartz, chlorite, talc, hornblende, feldspar, and argillite, and all difficulties of structure of the nature we have been considering vanish.

When the mineral oxide of iron alone was employed in the composition of a

layer, a bed of iron ore was the result; in the same way, when quartz alone was used, we find quartzite as the result; when these minerals were mixed, the silicious ores were the result, which are unfortunately twenty times more abundant than the pure ores. It is safe to say that the oxide of iron, although seldom pure, exists in all our rocks in greater or less quantity. Just the same may be said of the mineral quartz.

In brief, we may say that nature seems to have incidentally employed iron ore as a building material, just as she employed other, apparently, to her just as important materials. She does not seem to have changed her plans nor specifications when the iron ore course of crowning stones were laid.

Men, finding such ores infinitely more valuable than the other rocks, are led to suppose that some great convulsion, some means out of nature's ordinary course, were resorted to for its production.

Although foreign to our district, it is not improper here to notice the vein-like structure presented by most of the New Jersey magnetic iron mines. There it may be truly said that some phenomena of true veins can be found, and that many of the beds are worked successfully on a system of vein-mining. This fact does not shake the aqueous theory of origin which we are endeavoring to establish. The same folds exist there as here, only they are more regular and deeper. In this district, so far as yet made out, no fold is more than 175 or 200 feet from crown anticlinal to bottom of adjacent synclinal—deeper ones will undoubtedly be found—while to the east the azoic rock waves run much higher. In Sweden the ores have been followed down over 600 feet on a tolerably uniform underlay. Even in the New Jersey region the folds are not always so deep. A geological survey made by myself of the Mine Hill mines on the Durham estate, near the Delaware river, in Pennsylvania, which may be regarded as the extreme southwest end of the New Jersey iron region, developed a shallow synclinal basin, the axis of which pitched to the northeast. The result of this survey has since been published in Professor Cook's Report on the Geology of New Jersey.

A section of the Iron Mountain mine, Missouri, shows it to be a grand anticlinal fold; all of which proves that the same general law of structure holds for azoic ores thoughout this continent.

I might here enumerate numerous localities in this district presenting phenomena which can only be explained by supposing our ores to have been deposited from water, and afterward highly metamorphosed. All are familiar with the Cleveland knob; its whole surface striped with alternating red and metallic bands, which bend and double back on themselves, then reverse into an infinity of angular curves, but continuing always uniform in thickness, and parallel with each other, pointing back to the still water in which were originally laid down the thin alternate beds of ore and quartz. Who that has observed the working of our mines has not seen a thin knife edge of slate make its appearance in the midst of good ore, which, growing larger as it is followed in the direction of the bedding, may entirely crowd out the ore, and occupy the entire space between the walls of the bed, but more generally is satisfied with less thickness, and if followed will, after passing its maximum thickness, begin to thin out, and finally disappear in an opposite knife edge?

Perhaps the best place in the whole Lake Superior region at which to convince the skeptical that our ores are stratified, and are, in geological structure, precisely like the overlying and underlying rocks, is at Smith Mountain. Here nature has condensed, so to speak, the geology of the whole district in a small area.

Commencing at what is one of the youngest rocks in the Huronian System, so far as developed here, that is the upper, or conglomerate quartzite, we pass geologically down next over the specular hematite (sometimes magnetic), then the several diorites and schists alternating with ferruginous slates and flag ores to the lower quartzite which is seen reposing non-conformably on the protogine and gneiss of the Laurentian System, as first observed by Professor R. Pumpelly. These rocks standing on edge, and laid bare by wind falls and fires, are as easily studied as the specimens of a cabinet.

Some of the conclusions, theoretical and practical, concerning the ores of the Marquette iron district, which the facts

above cited, and others well known, point toward, are these:

(1.) These ores were deposited by water, at the same time and in the same manner as the underlying and overlying rocks with which they are associated.

(2.) There are several horizons of ore, the upper, or youngest, being the purest, and the one from which the specular hematites and magnetic ores now being shipped from the district are mined.

(3.) That the ores of the different horizons at places so closely resemble each other, that the best scientific and practical judges have mistaken one for the other. That all the mining failures in the district have come from this mistake—which can only be surely avoided by a full geological understanding of the locality.

(4.) That at certain places in the different horizons, from some cause, the ores have become partially or wholly disintegrated, and so changed chemically, as to produce Limonite; that is, the "soft hematite" ore of the district.

(5.) That while the several ore formations are tolerably regular in thickness, measured from over to underlying rock, in their interval structure they present considerable variety in their mineral composition, being made up of oxide of iron, generally mixed with red quartz, (so-called jasper), which is often in such quantity as to render the "mixed" ore valueless.

In addition to red quartz, there are frequently found lens-shaped masses, sometimes of immense size, of talcose and chloritic schists, the form of which is described above. These alternate with similar lenses of the pure and mixed ores, the whole presenting a structure not unlike that of the muscles of an animal. As if to still further complicate the question, the same lens or layer will change gradually, from a first class "shipping ore" to a worthless "mixed ore."

This arrangement closely resembles what Dana calls "ebb and flow" structure.

Sometimes these lenses of ore and rock terminate so abruptly at their edges and are so long in the direction of one axis as to be best described as pod-shaped. A writer in the "Annales des Mines" some years since described some of the ore deposits of Sweden as "flattened cylinder" shaped masses. Such are common in New Jersey.

(6.) That since the original deposition of the ore, which must have been in nearly horizontal layers, the beds have been subjected to great dynamic action, which has wrinkled, and folded, and broken, and in some instances almost capsized the whole series of associated rocks.

(7.) The extent of the ore in the Marquette district, at least so far west as the Washington mine, appears to be limited to a narrow synclinal basin, in which are several shallow folds. The exhaustion of any given length of this basin is certain to be attained if work be continued. The quantity of ore in a given length should be approximately computed by proper surveys.

(8.) These peculiarities of structure produce in the beds endless changes in dip, strike, thickness, and quality of ore, as well as in the nature of the containing walls; hence, presents, or will soon present some of the most difficult questions in practical mining. In a few fathoms I have seen a bed, not only change its dip from vertical to horizontal, but following its strike, the same bed has abruptly changed from a thickness of forty feet to as many inches. If, at the same time, as might easily have been the case, the same bed had changed from pure ore to nearly pure jasper, the metamorphose would have been complete, embracing composition, form and position.

Perhaps the most perplexing thing the underground miner will have to contend with is the varying and treacherous nature of the hanging walls when composed of the schists above named, which practically will not stand unless supported throughout their whole extent.

(9.) The best general principle on which to extract our ores, is undoubtedly the one which has been generally followed in the district; that is, find the ore, follow it by uncovering and quarrying as long as it will pay, then abandon the opening and find a vein, where the same process is repeated; using as little machinery and skilled labor as possible.

But when this system has exhausted all the ores that will pay under it, which will speedily be done at each mine, then there will be left large amounts of ore

which may be extracted by proper mining so as to give a fair return to mine shareholders.

(10.) Just what methods will be best suited to our case and to the labor and skill available here, experience must decide. It is safe to say that a knowledge of what has been done elsewhere under similar difficulties, coupled with actual experience in this district, would afford the best chances of success. Whatever plan be adopted, time will be required for its consummation; hence, preparations for underground work must be made in time, or production must cease when quarrying finds its limit.

(11.) It is not likely that narrow beds can ever be followed so far or under such difficulties in this district as in the magnetic regions of New York and New Jersey, because ore on the mine-bank is worth nearly twice as much there as here.

I suppose that two-thirds of the mines now wrought at a profit there, would have to be abandoned if here, as will appear from the following approximate comparison. The worked beds in the Marquette district average not less than two and one-half times as thick as those in Passaic, Morris and Sussex counties, New Jersey, and the ores produced contain, at least, 10 per cent more metallic iron; and there they lift their ore and pump their water, at least, five, and probably ten times as high as is necessary at our mines. But a 65 per cent. ore is worth on our mine-banks from $3 to $4, while in New Jersey a 55 per cent. ore is worth $5 to $6 at the mine.

(12.) It is not too much to expect of geological science, that if it be given the benefit of careful records of deep borings made in and about our mines, in addition to what can be seen here and elsewhere, it will in return be able to furnish the mine superintendent with such plans and sections, with predictions as to position and quantity of unseen ore masses, as will greatly aid him in the uncertain and expensive work of opening his mine by means of shafts and drifts, as well as in the location and erection of the necessary pumping and hoisting machinery.

PORTABLE CONDENSING ENGINE.

From "Engineering."

Nearly twelve months ago there appeared in this journal a letter from Mr. G. A. Haig, of Pen Ithon, proposing certain modifications in the construction of agricultural steam-engines, and suggesting, amongst other things, that they should be fitted with air-surface condensers. In a note which we appended to Mr. Haig's letter, we stated that such a condenser as that gentleman proposed would, if furnished with the requisite amount of surface, be too cumbrous for its intended purpose. Subsequently, Mr. Haig wrote some further letters on the subject, and in these latter communications he gave particulars of a series of experiments which he had carried out on a model condenser to ascertain the amount of surface actually necessary. Some of these experiments were conducted in our presence, and the results obtained showed that, with clean brass surfaces and a blast of air through the condenser so strong that the temperature of the air was only raised from 56 deg. to 128 deg. during its passage through the apparatus, about 1.18 lbs. of steam could be condensed into water at boiling point per square foot of surface per hour. Mr. Haig's deduction from these experiments was, that the area of condensing surface exposed to the action of the air current would have to be about four times that of the heating surface in the boiler; and taking into consideration the large size of the fans required to furnish the necessary supply of air, the power required to drive these fans, and some other details, he ultimately concluded, with us, that such condensers were practically inapplicable to agricultural engines, and he consequently abandoned the idea of having such a condenser applied, as he originally intended, to an engine which is now being built for his own use.

It is somewhat curious that just at the time that this subject was under discussion in our columns, and some two months and a half after the appearance of Mr. Haig's first letter, Mr. Frederick J. Bramwell should have taken out a patent for a

method of applying air-surface condensers to portable engines, which appears to us to be practically identical with Mr. Haig's. Inasmuch as the recent publication of Mr. Bramwell's plans in some of our contemporaries has again brought the matter before the public, it may be as well that we should point out the practical objections which exist to the system of condenser he proposes. Let us, for instance, to take an example which we employed on a former occasion, examine the case of an engine having 160 square feet of heating surface in the boiler, and evaporating, say, 800 lbs. of water per hour. Supposing, moreover, the steam to be discharged into the condenser at a pressure of 15 lbs. above the atmosphere, there would have to be abstracted from each pound of it 978 pound-degrees or units of heat, to reduce it to water at a temperature of 212 deg., so that altogether $800 \times 978 = 782{,}400$ units of heat would have to be abstracted per hour by the air passing through the condenser.

In Mr. Haig's experiments, to which we have already referred, the air passing through the condenser had its temperature raised from 56 deg. to 128 deg., or 72 deg.; but, inasmuch as agricultural engines are much used at times of the year when the atmospheric temperature is above 56 deg., it would probably not be safe in practice to furnish to the condenser a less supply than would suffice to abstract the requisite amount of heat with an elevation of temperature of 60 deg. The specific heat of air being 0.238, we thus have $\frac{782.400}{60 \times 0.238} = 55{,}721.5$ lbs. of air per hour as the supply necessary; this being equal, at a temperature of 62 deg., to 732,213 cubic feet per hour. Of the power requisite to furnish this supply we shall speak presently. According to Mr. Haig's experiments, it appears that 800 lbs. of steam per hour admitted to the condenser, at the pressure we have mentioned, could be condensed by about 680 square feet of clean metallic surface exposed to the air current; and, although we are far from believing that this amount of surface would be found sufficient in practice after it had become coated with grease, etc., carried over by the steam, yet we will for the present suppose it to be so.

Let us suppose the condenser to be provided with tubes 4 ft. in length, and, say 1 in. in diameter.* To make up the surface above mentioned, 650 such tubes would be required, these tubes having thus a united sectional area of $\frac{650 \times .7854}{144} = 3.545$ square feet. As these tubes would, under the circumstances we are proposing, have to pass 732,213 cubic feet of air per hour, the velocity of this air would be $\frac{732.213}{3.545 \times 60 \times 60} = 57.37$ ft. per second; and to give this velocity—even supposing no frictional resistance to exist—would require a pressure equal to a head of 0.75 in. of water, or, say 3.9 lbs. per square foot. But each of the 650 tubes would have to pass $\frac{732.213}{650 \times 60} = 18.8$ cubic feet of air per minute, and the frictional resistance due to this transmission would be equal to a head of about 0.68 in. of water, or, say 3.54 lbs. per square foot, so that the total pressure necessary to force the required quantity of air through the condenser would be $3.9 + 3.54 = 7.44$ lbs. per square foot. The net work to be done by the fan, therefore, would be to deliver $\frac{782{,}213}{60} = 12203.55$ cubic feet of air per minute against this pressure, a performance equivalent to $12{,}203.55 \times 7.44 = 90{,}794.4$ foot-pounds of work, or over 2.7 horse-power. This, it must be remembered, is the net work performed by the fan, and the power required to drive the latter, and consequently abstracted from the available power of the engine, would certainly not be less than 4-horse power, an amount equal to from 20 to 25 per cent. of the total indicated power which an agricultural engine would probably develop under the circumstances we are supposing.

So much for the power required to supply the air to the condenser; and now for some other considerations connected with the apparatus. Mr. Bramwell speaks in his specification of making the area of the condensing surface equal to twice the boiler-heating surface, when the condenser

* In the drawings attached to his specification, Mr. Bramwell shows condensers made up of a series of flat surfaces, forming rectangular channels; but, inasmuch as we have not precise information of the proportions he proposes to use, we have preferred in our example to suppose that 1 in. tubes are employed. We may add, that in order to give the necessary compactness to a condenser with rectangular channels, it will be almost compulsory to adopt proportions giving almost exactly the same frictional resistance as the tubes adopted in our example.

is merely required to reduce the steam to water at 212 deg.; but Mr. Haig's experiments clearly showed that such a proportion of surface would be very insufficient, and the allowance of 680 square feet of surface which we have supposed to be provided to condense 800 lbs. of steam per hour, is itself low. Even, however, if the tubes of such a condenser were made of thin brass, weighing but 1 lb. per square foot, they would weigh over 6 cwt.; and the weight of the whole apparatus, including casing, connecting pipes, fan, etc., would probably not be less than 13 cwt. or 14 cwt. Such a weight would be a most objectionable addition to a portable engine, and the apparatus, if employed at all, could probably be most advantageously arranged in a kind of tender hauled separately, a plan which, indeed, Mr. Bramwell suggests might in some cases be adopted. The use of the separate tender would, however, still further increase the cost of the apparatus, and we certainly can imagine but exceedingly few cases where this cost would be even approximately compensated for by the advantages which the condenser would give.

Before concluding this notice, it is desirable that we should make a few remarks on one point connected with Mr. Bramwell's plans, to which we have not yet directed attention. Mr. Bramwell, we should state, proposes to lead a portion of the air issuing from the condenser into the fire-box to support combustion, in some cases using this air to inject powdered fuel; and he says: "By taking care not to give the air which acts on the condenser too high a velocity, it will be found that the saving in fuel arising from using heated air for the combustion will largely compensate for the power required to set the air in motion." Now, in this we certainly cannot agree with Mr. Bramwell. The experiments to which we have already referred have shown that it is only by having a strong current of air through the condenser, and thus heating that air but 60 deg. or so, that the condensing surface required can be kept within anything like moderate bounds; and it thus happens that but a small proportion of the air passed through the condenser would be required for supporting combustion in the fire-box. In the example we have been considering, the evaporation of the 800 lbs. of water per hour would not probably require the consumption of more than 1 cwt. of coal in that time, and even if we allow 300 cubic feet of air per pound of coal burnt, we shall thus have but $114 \times 300 =$ 34,200 cubic feet of air per hour required for supporting combustion, an amount equal to less than 5 per cent. of that traversing the condenser. The 34,200 cubic feet of air supplied per hour to the fire-box would weigh about 2,600 lbs., and supposing its temperature to be 60 deg. above that of the external air, it would thus carry into the fire-box an amount of heat equal to $2,600 \times 60 \times 0.238 = 37,128$ pound-degrees per hour, or 618.8 pound-degrees per minute. Even, however, if the whole of this heat were transmitted to the water in the boiler, it would suffice for the conversion of less than $\frac{2}{3}$ lb. of water per minute into steam, even with the feed supplied from the condenser at a temperature of 212 deg., so that its effect in compensating for the power shown to be required to drive the fan, would be practically *nil.*

VELOCITY OF THE WIND.—Professor Huntington, who has taken up his residence on Mount Moosilauk, in New Hampshire, U. S., for scientific purposes, says the storm on the 2d inst. was very severe. The wind gauge was used, and it was ascertained that the wind was blowing at the rate of 95 miles per hour. In the afternoon the wind increased, and he went out with the "gauge" again. The rain was pouring, but he managed to hold the gauge for 5 minutes, and then, after four attempts, each time being thrown down by the wind, he succeeded in getting back into the house. This time they found that the velocity of the wind was 101 miles per hour, and Professor Huntington thought if the gauge had been properly held it would have shown that the velocity was 120 miles per hour. The walls of the house are of stone, but such was the force of the wind on the roof that every part of the inside trembled like a leaf, and so loud was the roar, that one had to shout to make the other hear, although not more than 6 ft. distant. The rain fell in torrents.—*Engineering.*

IT is stated that the intense cold in St. Petersburg, in the winter of 1867, caused solid blocks of tin to crumble and fall to pieces.

THE ACTION OF HOUSE SEWAGE ON LEAD PIPES.*

From "The Building News."

Mr Edward C. C. Stanford, F. C. S., referred to the panic which had recently been shown by the voluminous correspondence in the local papers regarding the alleged impurity of the water used for domestic purposes, and stated that it had revived the old question of the action of the purer kinds of potable water on the lead of the pipes and cisterns. The panic, known locally under the name of "death in the cistern," had been completely allayed by the remarkable unanimity of the reports prepared by Dr. Anderson, Professor of Chemistry, and Dr. Wallace, Analytical Chemist, and backed by an eminent medical authority like Dr. W. T. Gairdner. Notwithstanding, however, that the amount of lead was small, a sufficient quantity had been found in almost all the analyses of the cistern water to show the desirability of avoiding all suspicion of lead contamination, by adopting a constant high-pressure service in iron pipes, and, where they are required, of using cisterns of iron or slate. The author remarked that much attention had, from time to time, been directed to the action of the purer kinds of potable water upon lead; but it was somewhat remarkable that an equally important and much wider-spread evil of a similar character had escaped notice. He referred to the serious deterioration which lead pipes undergo which are connected with water-closets; and he brought this subject under the notice of the section in order that some light might be thrown upon the cause of the said deterioration. Dr. Fergus, a Glasgow medical gentleman, had the credit of first directing attention to the subject by tracing a close connection between the deterioration of the soil-pipes and the existence of various forms of low febrile disease in the houses into which, from the degenerated condition of the pipes, sewer gases make their escape. By means of sketches and used-up specimens of soil-pipes the author showed the nature of the action to which the pipes are subject from long use—the length of time varying from 10 to 16 years. Near the bend of the pipe leading from the closet the upper part becomes coated with a grayish white deposit that can be easily scraped off, and the interior of the pipe becomes pitted; while, exteriorly, the pipe is at first blistered at the parts corresponding to the internal "pits," and in course of time it becomes quite riddled with holes, and quite gnawed away as it were. Mr. Sanford had analyzed samples of the deposit from several soil-pipes, and had found from 86 to about 93 per cent. of the deposit to consist of plumbic carbonate, the other ingredients being calcic carbonate, silica, insoluble plumbic oxide, water, and organic matter. After noticing the chemical compounds which, in solution in water, act readily upon lead, the author said that the deterioration referred to was not due to those substances, inasmuch as they were found in the excreta, whereas the injury to the pipes took place in the air-space of the bend, and not in the water-space in which the "trapping" was effected. It has been remarked by plumbers that a piece of lime, or newly mixed mortar, in contact with a pipe, rapidly eats through it, probably by the lime combining with the carbonic acid of the outside film, and so cleaning the lead that the action of the air repeats the process. In the opinion of the author, alkalies would probably have the same effect as lime, and so clean the lead that a moist atmosphere would act on it. The effect of pure water on lead is first to dissolve it as oxide, and then this is precipitated as oxycarbonate, which is very insoluble, pure water only dissolving 1-60th of a grain per gallon. Water free from air does not act on lead; and the author therefore thought the action referred to might be due to the air carried down by the rush of water while the closet was acting, and by the carbonic acid, or by the ammonia of the gases of decomposition acting as a cleaner, the interior of the pipe being always in a moist condition. Mr. Stanford concluded by recommending the discontinuance of lead soil-pipes, and the substitution of earthenware siphons and flanged cast-iron pipes.

Dr. Fergus, in opening the discussion, recommended that soil-pipes should be ventilated, or that they should be used as the rain-water pipes. He gave some in-

* Paper read before the Glasgow Philosophical Society, by Mr. E. C. C. Stanford, F. C. S.

stances, in his professional experience, of the connection between such diseases as gastric fever, diphtheria, etc., and bad soil-pipes; and he strongly urged the periodical investigation of such pipes.

Mr. Sutherland suggested that the action might be due to sulphuretted hydrogen or acetic acid; but Mr. Stanford said that plumbic sulphide had never been found in his analyses.

Mr. Anderson believed that nitric acid, resulting from the oxidation of ammonia, might have some influence in producing the injurious effects on the pipes. This view was supported by Mr. Hutton and Mr. Tatlock.

ON THE DISTRIBUTION OF RAIN.

From "The Canadian Naturalist."

The geographical distribution of rain over the surface of the globe may be said to be proportioned to temperature, its humidity to the tides or fluctuation in the atmosphere, as indicated by the barometric variations, to changes of temperature, and to the configuration of the earth's surface.

The conditions necessary to the formation of rain are the presence of clouds (although some observers have recorded rain falling from a cloudless sky), to that of the cirrus (or snow cloud) at a high elevation, and at a low temperature (some 40 deg. below zero), together with the cumulus (or vapor-cloud). These, commingling by moist air-currents being forced into the higher region of the atmosphere by colder, less humid, and consequently heavier currents from beneath, form together the nimbus (or rain-cloud). These induce a change in temperature and electrical action, conditions necessary to produce rain. This is carried by clouds and currents of wind and distributed over the lands of our continents, thus watering the earth, supplying vegetation, and the various wants of mankind, and returning again by the rivers to the sea. From the surface of the ocean pure aqueous vapors are constantly ascending to supply the unceasing requirements of the organic and inorganic world.

Rain clouds are attracted to certain localities more than to others, for it was shown that at Ulleswater (England) the great heat of 1866 caused a great increase in the amount of rain, owing to its condensation by the mountains in that district. But beyond the formation of the surface of our globe, there are other conditions which supply natural conductors, such as the pointed extremities of the leaves of trees and of plants. May not our primeval forests have given rise to a different meteorological condition of a former world? The great coal formations may be taken as an example in illustration of this.

Many countries have been made sterile by cutting down indiscriminately the whole of the trees. Such, indeed, is actually the case in the recent deserts of Syria, Chaldea, and Barbary. The "oases" of the desert are nothing more than a few trees purposely left as a shade for the weary traveller.

The value of several estates in the West Indies has been greatly diminished by the cutting down of the trees upon them, and the rain-fall over large regions of our continent is much diminishing, owing, no doubt, to the large and extensive clearances of our forest; while, on the other hand, the rain-fall in the upper province of Egypt has been increased tenfold by the planting of twenty millions of trees by Mehemet Ali.

Until two years ago rain in that province was unknown; but in twelve months ending April last, there were actually fourteen days on which rain fell, and later there fell a heavy shower—a phenomenon which the oldest Arab had never witnessed. Here we see rain returning to the desert on restoring trees.

In Spanish America, lakes have had their area diminished and their shores dried from the general removal of the trees by the Spaniards; but now that cultivation has been resumed by the enterprising Americans, these lakes are being again filled up with water, and the shores are once more plentifully supplied with rain.

Extensive drainage, although beneficial to the rapid growth of plants and to the profit of the agriculturist, may also tend

to diminish the rain-fall by robbing the springs of their supply, and by conducting the surface water more rapidly to the rivers and to the ocean.

Those lands near the sea over which the wind transports the aqueous vapor there acquired, are, as a general rule, the most plentifully watered, while those distant from this source receive less in amount; these facts are fully borne out by actual observations. And may not the diminished rain-fall in England be attributed in a great measure to the extensive surface drainage by drain-tiles and other methods, which are resorted to to promote the rapid growth and excessive yield of grain and some of the other agricultural products?

It will be seen that rain increases with the temperature, from the fact that hot air holds more water suspended than cold. The humidity of the atmosphere attains its maximum at the sea shore, and there tends to produce the greatest amount of precipitation. These causes are always present, but in a modified degree, and frequent, though small, showers are the necessary consequence; heavy and violent rain storms are of rare occurrence there.

In proportion as the mercurial column in the barometer falls, there is more chance of rain being formed, inversely in countries with a high barometric pressure, such as on the 30th deg. of latitude, where there is very little rain. Such regions have a tendency to become deserts.

Variations of temperature and irregularities of climate increase the showers of rain; and the formation of the soil plays also an important part in the production of rain, for ascending concave surfaces of soil receive a maximum, more especially when exposed to rainy winds, and more rain falls in *wooded* than in *bare* districts.

It rarely or never rains on the coast of Peru, in the great valley of the River Columbia, in that of the Colorado in North America, the Sahara in Africa, and the desert of Gobi in Asia, while in Patagonia and Chiloe it rains almost every day.

Days of rain are more numerous in high than in low latitudes.

In the region of Calmus it rains during a part of every day, the fall amounting to 225 in. in the year.

The heaviest fall of rain on our globe takes place on the Khasia Hills, to the north-west of Calcutta, and amounts to 600 in. annually.

The greatest amount which has fallen in the vicinity of Montreal in one hour was 1.110 in.

These observations extend over a period of upwards of twenty years.

Below is a table showing the annual mean amount of rain-fall at some of the principal stations on our globe. The amount is in inches and hundredths:

	In.
Madras	55.10
Bombay	75.00
Canton	78.00
Sierra Leone	87.00
Rio Janeiro	89.00
Barbadoes	72.00
Vera Cruz	183.00
Bergen	89.00
Stockholm	19.67
Copenhagen	18·55
Brussels	29.96
Naples	29.94
Rome	30·86
Paris	22.64
St. Petersburg	17.65
London	22.00
Oxford	27.10
Cork	40·00
Dublin	24.00
Glasgow	21·33
Aberdeen	28.87
Manchester	36.00
Liverpool	34.00
New York	43.50
Cambridge	44.48
Albany	40.67
Baltimore	40.98
New Orleans	52.31
Cincinnati	48.63
San Francisco	22.00
Washington	41.20
Halifax	43.44
St. John, N. B	42.10
Toronto	31.50
Montreal	36.00
Quebec	39.10

It is stated that Dr. McQuillen has exhibited, in the Microscopical Department of the Academy of Natural Sciences at Philadelphia, slides of blood corpuscles of men and the lower animals, to which chloroform and nitrous oxide had been administered, to show that there was no morphological change in these bodies after administration of anæsthetics, as stated by certain physiologists in England. He showed specimens also in which, the blood corpuscles having been brought into actual contact with chloroform and ether, disintegration had taken place.

THE GUNS OF THE HERCULES.

From "Engineering."

We are told that the guns of H.M.S. Hercules have been disabled, that now our finest fighting ship is of no use except as a ram, that probably she will have to return to England forthwith to refit, and that all this dreadful mischief has been occasioned by the breaking up of the Palliser shots during practice before they passed the muzzle of the gun, with the result of seriously scoring the tubes. Says the "Times:"

"Whether the damage is of a sufficiently serious nature to cause the ship's immediate return to England or not, the fact remains that the guns of our heaviest broadside armored iron-clads have been for a time disabled by their own shot, and that every time any gun fires these projectiles there is attached the probability of similar disadvantageous results to the gun being attained. The accident to the Hercules's guns brings us no new knowledge on the subject. Every one was aware from the first hour of the introduction of the Palliser chilled shot into the service, of their brittle character, but it required that their destructive character when breaking up in the tube of a gun should be exhibited upon such costly weapons as the 18-ton guns of the Hercules, and at a distance from a home port, before the danger of such a mishap occurring in a probable time of war could be properly appreciated."

From this text the "Times's" leading article is written, and it points out the grave necessity of proving definitely how far the Palliser shot really are reliable, and then, leaving the direct question, it turns to the consideration of the relative penetrative power of the Palliser and Whitworth projectiles, when fired against oblique surfaces. This is a highly important question, but it is one entirely apart from the breaking up of shot in a gun, although the "Times" apparently does not think so, if an opinion may be formed from the amount of space it gives to the reprint of a discussion which followed Sir Joseph Whitworth's paper on the penetration of armor plates, read before Section G of the British Association at Exeter last year.

The whole story of the disablement of the Hercules, as recorded, is, however, marvellously distorted. The facts were these: only one of the Hercules's 10 in. guns has been damaged seriously, and that was occasioned by the bursting of a chilled iron shell, loaded with a 10 lb. charge, in the bore of the gun, an accident which split the steel tube for a distance of two or three feet.

Thus, instead of the whole armament being disabled by the breaking up of the shot, and consequent scoring of the steel barrels, we have the "A" tube of *one* gun split by the premature explosion of a shell —a very different matter.

Putting aside the magnificent exaggeration of the "Times," and regarding the casualty as it really occurred, it is serious enough, and the cause has yet to be explained. It was a chilled shell that caused the damage, and we have Major Palliser's assurance that they were not of his design, but of a pattern avowedly so bad that the few which had been made were intended for remelting. But it by no means follows that, defective as the shell was in pattern, it ruptured from brittleness of material. It is no very uncommon thing for shells to burst in the barrel of a gun, as, for instance, some two years ago, when the muzzle of a 7 in. gun was blown off by the premature explosion of a common shell. But it is not necessarily the failure of the metal which brings about the catastrophe; it is more probably some slight retardation or unevenness in the flight of a projectile as it leaves the gun, which is sufficient to discharge the fuse; or the latter may be accidentally too sensitive; and if such a cause induces a premature explosion, the consequences will be equally disastrous, whatever the material of the projectile.

It is too soon, however, to speculate upon the precise causes which caused this accident to the Hercules's gun; in a few days, however, the official particulars will have been made public, and then we shall be enabled to form an opinion. Meanwhile it is satisfactory to know that the alarming reports published have so slight a foundation.

That the steel tube of the 18-ton gun cracked so extensively from the effects of

the explosion is, however, an important fact, and points out the weakness of our service guns, not only of the heavier calibres, but of the smaller bores. The barrels are all made of Firth's steel, carefully tempered in the solid, and afterward bored, and, though every care is devoted to their construction, several casualties similar to that on board the Hercules have occurred. It is certain that coiled iron tubes show a greater power of resistance, owing to the different arrangement of the material. It is only recently that one of Palliser's converted guns, lined with a coiled tube, successfully resisted the explosion of five common shells, purposely burst in the gun, and each loaded with a heavier charge than that which disabled the Hercules's 400-pounder, the only damage wrought being a bulging of the tube. But whether this special advantage possessed by the coiled tubes counterbalances the superiority of the steel barrels in many other respects, has yet to be decisively proved.

The time may be soon coming when a new chapter in the history of our heavy ordnance will be commenced, and the Whitworth system may at last supersede that which, originally Sir William Armstrong's, has developed into the Woolwich service gun. But it remains to be proved how great a practical superiority exists in the former plan—a long, slow, and costly process. With regard to the relative capabilities of our ordinary projectiles, as compared with the Whitworth flat-headed shot, for penetrating inclined surfaces, the challenge of Major Palliser is well calculated to settle the long disputed question. But when the practical superiority of the Whitworth system of guns and projectiles over those of the service has been ascertained beyond a doubt, the time will have come to abandon the latter, and start afresh with the former, and its advocates may rest assured that such a change will not be precipitated by unreasonable and exaggerated statements of the deficiency of our existing armaments.

THE CENTRAL IMPERIAL SCHOOL AT PARIS.

From "The Builder."

The Central Imperial School of Arts and Manufactures is a highly esteemed and most important educational establishment. By its means many pupils who cannot avail themselves of the opportunities offered by the great Polytechnic School, are enabled to obtain a most complete and practical education.

For the purpose of comparison, we will give a short sketch of the Polytechnic School. It was founded in the year 3 of the Convention (1794), for the instruction of young men in mathematics and drawing for the artillery and engineer corps. None but candidates who can pass a very severe examination in mathematics are admitted. Its effort has always been to educate, above all things, good engineers; and some of the most celebrated military and civil engineers have been bred within its walls. Still, the time required by this school (7 years), including the preparatory and complementary studies, is much too long for candidates who are anxious to commence their practical and money-earning career as soon as possible. The difficult preliminary examination also excludes a great number of candidates. Again, more than half the pupils of the Polytechnic School choose the military service, whilst the greater portion of the other half abandon the civil services to follow scientific pursuits. This is why the admirable Polytechnic School has never been able to satisfy the ever-increasing demands of industry.

The Central School, therefore, fills up a manifest deficiency in the French system of technical instruction. It was founded in 1829 by the celebrated chemist Dumas, assisted by three other gentlemen, without any aid from the Government; but, after some years of success, it first of all passed into the hands of a proprietor, and was then transferred to the State. In the Central School have been educated a considerable number of able engineers, who have taken high rank as constructors of railways, etc. Many directors, managers ,and other functionaries of important industrial establishments, civil engineers, mechanical engineers, architects, etc., have emanated from this school.

The Central School is very popular,

even with persons of narrow means, though what in France is held to be a high charge (800 francs, £32 a year) is demanded from pupils. The Government and several of the departments have founded scholarships in favor of the sons of parents in very humble circumstances, and in some cases money for board and lodging has been added. The sons of rich parents pay for their education, as they naturally ought; whilst the doors of the school are also open for the sons of artisans, who have given proof of the talents necessary to profit by the instruction.

At the Central School the pupils are compelled, whatever may be the careers they intend to follow, to attend all the courses, and to pass very strict and frequent examinations. During the first year the instruction is purely theoretical. In the second and third years theory and practice are blended. The teaching is not confined to unaided oral instruction; for laboratory experiments, and mineralogical and geological excursions, are made use of to complete what the lectures of the professors have commenced. As we have stated, there are frequent compulsory examinations during the courses and at their close, in addition to which there are searching examinations at the termination of each year's studies. The effect of this system is to keep the pupils always up to their work. Discipline is also strictly maintained.

The Central School is quite international and cosmopolitan in its character; pupils of all nations are admitted on the same footing as natives of France. Not a country in Europe is without a representative, and at one time or another pupils have come here from every part of the civilized globe.

There can be no better way of showing what this institution imparts to its scholars than the quoting in full the programme of the three years' studies.

First Year.—Analysis and general mechanics, 60 lessons; general physics, 60 lessons; inorganic and organic chemistry, 60 lessons; theoretical and applied kinematics, 24 lessons; construction of machines, 20 lessons; hygienics and applied natural history, 20 lessons; mineralogy and geology, 30 lessons; architecture, 10 lessons; industrial drawing, 20 lessons.

Second Year.—Applied mechanics, 60 lessons; strength of materials employed in machines and constructions, 24 lessons; construction and mounting of machines, 60 lessons; analytical and industrial chemistry, 40 lessons; metallurgy, 20 lessons; civil constructions, 60 lessons; industrial physics, 45 lessons; industrial and commercial legislation,—ceramics, 8 lessons; dyeing, 12 lessons; glass-making and mining, 20 lessons.

Third Year.—Applied mechanics, 60 lessons; construction and erection of machines, 55 lessons; analytical chemistry, 20 lessons; industrial and agricultural chemistry, general metallurgy, and metallurgy of iron, 60 lessons; mining, 20 lessons; public works, 60 lessons; steam-engines, 35 lessons; railways, 40 lessons; naval constructions, 25 lessons.

In addition to the above the following practical exercises and studies are required:—

First Year.—Various chemical manipulations; exercises in general physics, stereotomy, and taking of plans; architectural and topographical designs, and working drawings; problems in the infinitesimal calculus, general mechanics, and general physics. During the vacation, after the first year's studies, the pupils are expected to make plans of buildings and machines; also to write an essay on the resistance of materials.

Second Year.—A practical essay on the flow of gases, with the aid of an anemometer and a ventilator; each pupil to draw up a paper on the subject. Construction with bricks according to given plans of various kinds of chimneys, a baker's oven, a lime-kiln, a hot-air stove, etc. Each pupil to make a survey and draw a plan of a watercourse, and measure the volume of water in a stream; a paper to be sent in on the details of these operations. Practical exercises in a factory on the construction of machines. Twenty-seven manipulations in analyzing and assaying. Drawings and projects of machines and buildings. During the vacation after the second year, the pupils to visit manufactories, etc., and to hand to the director, on resuming their studies, a diary, giving a summary account of the studies made and the factories visited; an album containing notes and sketches made on the spot; fair copies of the most remarkable objects contained in the album, and a paper on questions in applied mechanics.

Third Year.—Projects in two series: the

first on the more important subjects in all the courses; the second on subjects connected with machines, buildings, metallurgy, and chemistry.

A NEW WATER-COLUMN MACHINE.

Translated from Der Praktische Maschinen Constructeur.

Among the machines for raising water by the work of water, the simplest and most effective are those in which power is derived from a great head, and raises a volume of water to a height less than the head. In this way a small constant supply of water, with sufficient head, will raise a large quantity. Again, a large volume of water may be made to raise a smaller quantity to a higher level.

Fig. 1.

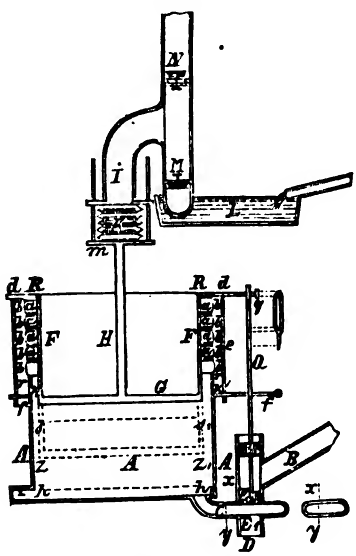
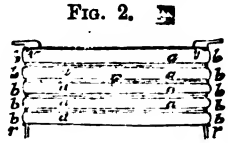


Fig. 2.



Very little use has been made of those machines by which water is raised to a higher level by means of columns from 3 to 10 metres in height, giving a quantity small in proportion to the diminution of the head. The reason that other water machines, more complex, are employed when these would answer, may lie in the difficulty of fitting the piston, which must be of so large dimensions as not to cause a great loss of work from resistance.

The figures represent machines in which an attempt is made to diminish resistance as much as possible, to make motion smooth and elastic, and to dispense with such contrivances as are required in the ordinary machines to complete the motion of the guide piston after the water in the cylinder is cut off; a necessity caused by the non-elasticity of water.

The first of these objects is accomplished by the peculiar construction of the piston and the cylinder; the second by the use of water and air together.

The single-cylinder machine (Fig. 1), consists of the following parts: A cylinder, A, of wood or iron, which communicates at D with the air, and is connected with the tube, B, which leads to the reservoir of supply. In the common machine this connection is regulated by the piston, E, so that when the communication is made with the air, that with the tube, B, is closed, and conversely. Above the cylinder is the air-tight cylindric part, F (Fig. 2), which consists of steel rings, *a a*, joined by a soft elastic rubber membrane, *b*; for this may be substituted soft leather. The connection with the piston at *r*, is made air-tight. The driving piston moves the piston, *m*, by means of the rod, H; this piston, with K, closing the tube, I, which is air-tight below. The part K, constructed like F, imparts motion to the piston, *m*, which, by its downward stroke, draws water from the reservoir, L (supplied from the same source as the tube, B, or from any other); and by its upward stroke drives it into the tube, N, raising it higher at each stroke.

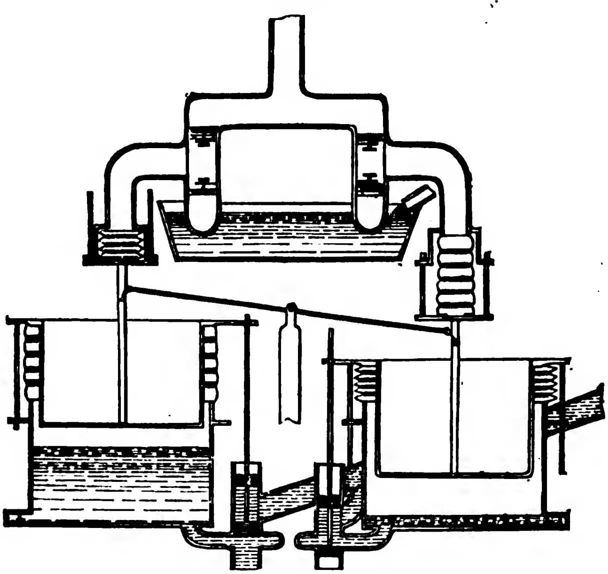
Upon four sides of the collar, R, R, are rods, *d* and *e*, which move in well-oiled guides, and by this means steady the motion of the piston (G). The part K can be removed from the lower part of the tube, I, and for it an ordinary piston may be substituted.

The piston, E, is moved by a rod, Q, which has on its upper part a long slot on

which the part g moves. To prevent pressure from one side on the piston, m, a counter-piston is set at the proper height.

The action of the machine is as follows: At first, the tube, B (Fig. 1), is empty; F is compressed by the weight of the piston, G, which descends to ZZ″; K is expanded, and the guide-piston takes the position E. To start the machine, water is admitted at B, and passes through C to the cylinder, A. Until the water reaches the level, hh, there is no increased pressure on the piston, G, the pressure of the atmosphere which can escape through the floating valve, remaining constant. When the water has passed the level, hh, the valve, h, closes, so that as the level of water rises, the air in the cylinder becomes condensed and by its pressure raises the piston, G. At the same time, K is compressed and works as long as the piston remains at E; that is, until the arm, g, reaches the upper end of its rod and raises it to the position, E. The water now ceases to rise in the cylinder, and the piston, G, is raised a little by the expansion of the condensed air. The point E should be reached before the water has reached KK, so that the portion F may not be wet. In the figure, ss is the highest level of the water in the cylinder. The air is now admitted through D into the cylinder, A, and the water escapes through D.

FIG. 3.



This causes the air above the surface of the water to expand, and the piston is forced down by the atmospheric pressure and its own weight until the arm, g, again connects with the rod, and the piston takes the position E, which is made to happen at the time when the water has, by a suitable adjustment, descended to hh.

The construction should be so arranged with reference to the height of the water-power and the required work, that after the rising of the water level above hh, only so much air remains in the cylinder as is necessary to complete the motion of the guide-piston; since a greater quantity would cause a loss of work.

The size of the working parts, G and m, must be regulated according to the head of water-power and the height to which water is to be forced. For example, if the head of supply is 4 metres above the line, KK, and water is to be raised to a height of 20 metres, the working surface of m (resistances not taken into account) should be ^{1} of the working surface of G, and a quantity of water equal to $\frac{1}{6}$ of that discharged at D will be raised to the required height (loss of work not considered).

In comparison with the work of ordinary machines (in which a contrivance like F could not be used with advantage on account of the great pressure), this

machine works with greater expense of power; but its quiet and continuous motion without shock, and its simpler construction, compensate for this defect.

AIR IN COAL GAS.

From "Engineering."

Although it has long been a recognized fact that the illuminating power of coal gas is diminished by an admixture of atmospheric air, yet but comparatively few experiments have been made to determine the amount of this deterioration under various circumstances. In 1860, however, Mr. Carl Shultz made some investigations connected with the subject, and before speaking of some more recent researches, it may be interesting to state the results he arrived at. One principal deduction made by Mr. Shultz from his experiments was, that the illuminating power of ordinary coal gas is diminished to the extent of half of one candle for each one per cent. of air present; but in the case of very rich bog-head cannel gas he found a remarkable exception to this law. This gas, he found, when burned in an Argand burner, might have as much as 12 per cent. of air added to it without diminishing the illuminating power of the flame; but, curiously enough, if an intensity burner was substituted for the Argand, this gas was found to conform to the law which we have already mentioned as applying to ordinary gas. This result, we are inclined to think, must have been due to the fact of the gas when burnt pure in the Argand burner not receiving a sufficient supply of oxygen, and that, on the other hand, when the mixture of gas and air was burnt, this deficiency of oxygen was made up by that of the air mixed with the gas. In 1862, also, an important *memoire* by MM. Audouin and Bérard "on the various burners employed in gas lighting, and researches on the best conditions for the combustion of gas," was published under the auspices of the French Government, and this *memoire* contains particulars of some other experiments on the effects of mixing air with coal gas. MM. Audouin and Bérard employed in their experiments two gas-holders, one charged with a standard gas, while the other contained gas of the same quality, but mixed with a certain percentage of air, the effect of which it was desired to ascertain. The illuminating power of the standard gas is not stated, but it probably did not exceed 12 candles. Each gas-holder supplied a bat's-wing burner, regulated to burn 140 litres (4.76 cubic ft.) of gas per hour, and the illuminating powers of the two flames were compared, that of the pure gas being taken as the unit. These experiments showed that the loss of illuminating power due to various percentages of air was as follows:

Percentage of air mixed with gas.	Percentage of loss of illuminating power.	Percentage of air mixed with gas.	Percentage of loss of illuminating power.
1	6	9	64
2	11	10	67
3	18	15	80
4	26	20	93
5	33	30	98
6	44	40	99
7	53	45	100
8	58		

It will be seen from the above table that for small additions of air, say up to 3 or 4 per cent., each percentage of air added reduced the illuminating power of the mixture about 6 per cent., while as the quantity of air was increased its comparative effect also increased until 6 per cent. of air was present. After this the comparative effect of each successive addition of air diminished, as shown in the table, the last 5 per cent. of air only diminishing the illuminating power 1 per cent.

We now come to some valuable researches on the effect of mixing gas with atmospheric air, which have been lately carried out by Mr. B. Silliman and Mr. Henry Wurtz, of New York, who have contributed a paper on the results of their experiments to the "American Journal of Science and Art." Messrs. Silliman and Wurtz's experiments were conducted at the experimental laboratory of the Manhattan Gas Light Company of New York, and they appear to have been carried out

with the greatest care. The apparatus employed consisted of a pair of gas-holders, each having a capacity of 10 cubic feet, these holders being fitted with connections, so that either could be used independently, or that the contents of one could be transferred to the other, and *vice versâ*, for the purpose of obtaining a thorough mixture of the gas and air. The air was admitted to the gas-holder by opening a cock and adding weight to the counterpoise, the amount thus admitted being roughly measured by means of a scale attached to the drum of each holder. The rough measurement thus obtained was subsequently checked by an eudiometrical analysis of each mixture, as it was found that this was the only way in which the relative proportions of gas and air present could be accurately ascertained. A prior analysis of the ordinary street gas used on each occasion was also made, and these analyses showed that the average amount of air present in this gas was rather over 1.6 per cent. The illuminating power of each mixture was ascertained by the Bunsen photometer, 15 successive observations of one minute each being made in each case, and the average being taken. The gas was burned in a 15-hole standard Argand burner, consuming 5 cubic feet per hour.

Messrs. Silliman and Wurtz's deductions from their experiments are: 1st. For any quantity of air, less than 5 per cent., mixed with gas, the loss in candle power due to the addition of each 1 per cent., is a little over $\frac{6}{10}$ths of a candle (0.611 exactly; above that quantity the ratio of loss falls to half a candle power for each additional 1 per cent., up to about 12 per cent. of air; above which, up to 25 per cent., the loss in illuminating power is nearly $\frac{4}{10}$ths of a candle for each 1 per cent. of air added to the gas; and 2d. With less than one-fourth of atmospheric air, not quite 15 per cent. of the illuminating power remains; and with between 30 and 40 per cent. of air it totally disappears. These results, it will be noticed, differ to some slight extent from those obtained by MM. Audouin and Bérard, and already referred to by us. The differences, however, are not more than may be readily accounted for by the difference in the class of burners used in the two sets of experiments, and by the fact that the gas experimented upon by Messrs. Silliman and Wurtz had an average illuminating power of about 15 candles, this power being probably considerably greater than that of the gas used by MM. Audouin and Bérard.

The experiments we have quoted strongly point to the necessity which exists for carefully preventing the admixture of atmospheric air with coal gas, and they go far to explain the fact that in small gasworks—where the facilities for such admixture are proportionately greater than in larger establishments—gas of inferior illuminating power is frequently produced. The manner in which the small percentages of air act in producing such an important reduction in the illuminating power of gas cannot as yet be said to be accurately determined; but Messrs. Silliman and Wurtz incline to the belief that the effect is not merely due to the interior combustion which takes place in consequence of the presence of oxygen, but that it is to some extent occasioned by the diluting power of the associate nitrogen, this gas absorbing a portion of the heat produced, and thus reducing the flame temperature. With a view of obtaining further information on this subject, and of throwing more light on the discovery made by Mr. Schultz, that rich cannel gas has its illuminating power increased by the addition of a certain percentage of air, Messrs. Silliman and Wurtz propose, at their earliest convenience, to make further experiments on the addition of oxygen to gas of high illuminating power, and also on the effect of making additions of carbonic acid.

SPECTROSCOPIC OBSERVATIONS.—Father Secchi has communicated a note to the French Academy relative to recent spectroscopic observations on Uranus. He found absorption bands different to those met with in the solar atmosphere. He also recorded some results of his investigation of Neptune. Its light gives three principal bands in the spectrum; one is situated between the geen and yellow, and another is in the blue. The spectrum accords with the green color of the planet. He reports that at Rome, during the early part of the night of the 13th—14th the sky was clouded; from 2.35 to 3.4 A.M. the sky got clear, and he registered 186 meteors, which seemed to radiate from some point in Leo

THE ECONOMICAL PURIFICATION OF ZINC CONTAINING IRON.

BY W. H. CHANDLER.

From "The Chemical News."

In the galvanizing of iron, the article to be galvanized, after being thoroughly cleansed, is dipped into a kettle of molten zinc, which forms an alloy with the iron at the surface of contact, and by repeating the dipping, the thickness of the superimposed zinc may be increased at pleasure. In the prosecution of this manufacture, the zinc is held in large iron troughs or kettles, which are rapidly corroded in those portions nearest the fire. An alloy of zinc and iron is formed, to which also the articles being galvanized, in some degree contribute. This alloy being heavier than the purer zinc, sinks to the bottom, and, from time to time, is removed by perforated ladles.

The composition of the alloy is of course somewhat variable, depending upon the temperature and fluidity of the zinc, and the careful straining from the fluid metal. The two analyses here given, were made by the writer a number of years since:

Zinc	94.27	94.15
Iron	5.46	5.00
Lead	0.27	0.56
Tin	trace	0.29
	100.00	100.00

These samples were taken from a remelting of a large quantity of the alloy, which is the only practicable method of obtaining a fair average specimen.

The quantity of this dross or refuse is quite considerable, amounting probably, in the United States, to several hundred tons per annum. Formerly it was sold for use in coarse brass castings, and to some extent it was re-distilled. At one establishment in Boston, circular clay retorts, similar to those in use in the gas manufacture, were employed, the molten alloy being introduced through an inverted siphon in the iron mouthpiece and the condensing tube connected with the reverse end of the retort, dipping in a pot of molten zinc; thus all access of air to the interior of the retort was prevented, and little or no oxidation of the zinc occurred.

Several years since, a small lot of this refuse zinc was received at a metallurgical establishment in Massachusetts, in which the writer was employed as chemist, and in experimenting upon it, one of the foremen of the establishment originated a method by which the zinc could be obtained quite free from iron. Finally, after rebuilding his furnaces and in various ways altering and modifying his manipulations, the samples of purified zinc being analyzed after each alteration of the process, a good commercial article was obtained, containing only $\frac{1}{10}$ of one per cent of iron.

The process consists in melting the refuse in an iron kettle, raising the heat nearly to the point of volatilization of the zinc, and then, by a proper regulation of the heat, cooling the mass slowly from the bottom, by means of a special arrangement of flues. An alloy of zinc and iron, containing a much larger percentage of iron than the original refuse, gradually forms, falls to the bottom of the kettle, and is removed by a perforated ladle, while the fluid metal is much purer. The quantity of alloy to be ladled out depends upon the impurity of the original refuse. The purified zinc and the concentrated impurity are melted in separate kettles, and each treated as in the first operation.

One more fusion and refrigeration of the purified zinc and the still more impure zinc, renders the former a good commercial spelter, and the latter too impure for further economic treatment.

This process is the reverse in its reactions, from Pattison's process for desilverizing silver-lead ores. In the latter case the purer lead crystallizes from the more fluid lead and silver, whereas in the former the more impure alloy separates from the purified zinc.

The residue from this process, which is sold for distillation, consists of hexagonal prismatic crystals of a fixed alloy of iron and zinc, loosely agglomerated together so as to crumble in the hand.

When the operation of refining is badly conducted, more or less zinc acts as a solder for the crystals. They are beautifully iridescent, exhibiting all the colors of the rainbow, owing to a surface oxidation. A number of specimens of various

colors were selected for analysis and showed a composition of—

Zinc	90.50
Iron	9.50
	100.00

Upon fusing these crystals, which requires a high temperature, and cooling as before, a small percentage of purified zinc is obtained, and an alloy containing as much as 12½ per cent. of iron. This is compact, somewhat brittle, and exhibits no evidences of crystallization.

This last-mentioned fusion is not made in practice, as the great heat required for its accomplishment rapidly burns out the iron kettles.

By a similar process lead has been removed from zinc with great accuracy, the amount obtained closely approaching the quantity therein. From a lot of Silesian spelter was separated lead perfectly malleable, and containing scarcely a trace of zinc. The purification of the lead, obtained from the process of desilverization of silver-lead by means of zinc, could undoubtedly be accomplished by a modification of this process.

THE WATER SUPPLY OF PARIS.

From "The Engineer."

Paris presents some facilities, but more difficulties, as regards water supply. The city is surrounded by heights which present good positions for the establishment of reservoirs; but the sources of supply at hand are insufficient, and good water a long way off. The water brought by certain canals is not potable, so that it has been necessary to make separate arrangements for the supply of the inhabitants and the watering of roads and irrigation of the parks and public gardens.

The supplies are obtained partly from rivers and partly from springs. The former are supplied by the canal of the Ourq, which yields 105,000 tons; steam pumps on the Seine at Port à l'Anglais, 6,000 tons; ditto, at Maison Alford, 8,000 tons; ditto, at Quai d'Austerlitz, 22,000 tons; ditto, at Chaillot, 38,000 tons; ditto, at Autuil, 3,000 tons; Neuilly, 5,000 tons; Saint Ouen, 6,000 tons; the hydraulic works of St. Maur, 15,000 tons; giving a total of 208,000 tons.

Practically, however, this supply is greatly reduced by various causes, such as drought, which causes that of the canal of the Ourq to fall to 95,000 tons, repair of the machinery, etc.; so that the average that can be counted on safely is not more than 170,000 tons. Lately, however, the suply of the St. Maur works has been raised to 40,000 tons, so that an approximative total of about 200,000 tons has been reached. The spring water is derived from Arcueil, which yields 1,000 tons; the artesian well of Grenelle, 600 tons; the artesian well of Passy, 8,000 tons. In addition to these the waters of the Dhuis, which recently supplied 24,000 tons, have lately been increased to 49,000 tons by the construction of secondary aqueducts.

The distribution of these various supplies is a follows: The waters of the Ourq serve five arrondissements in the centre of Paris and the lower portions of ten other departments, as well as a part of the Bois de Boulogne. The waters of the Dhuis are reserved for the private service of three arrondissements in the outer circle of the city and of the higher portions of four other arrondissements. The waterworks of St. Maur supply the Bois de Vincennes. The water of the Seine raised by the pumps at Chaillot supplies the Tuileries, the houses of the ministers, the hospitals, the higher portions of old Paris, and a large portion of the outlying districts on high ground. The other waterworks serve their respective districts.

The Passy artesian well supplies the Bois de Boulogne; the water is hot, and loaded with sulphuretted hydrogen, like that of Harrowgate. The waters of Arcueil and of the artesian well of Grenelle are used to supplement the waters of the Seine.

At present the outlying quarters of the city—those which were but recently taken within its limits—are the best supplied with water; nearly all that of the Dhuis, besides that of the Seine, taken above the city, being reserved for this purpose, while the central and older parts of Paris are scarcely better off than they were in 1856, when the distribution only amounted to

80,000 tons. This latter fact has its origin in a variety of causes: in the first place, since 1857 the drought has been greater than ever occurred during the seventeenth, eighteenth, and nineteenth centuries; many sources have been completely dried up, and the yield from others has been diminished in an extraordinary degree. As regards the Seine, the conduit pipe of the water-works at Chaillot, which was established according to low-water mark in 1719, became quite uncovered towards the end of 1865, and the city was deprived at once by that occurrence of 38,000 tons of water per day, and that not only at the driest part of the year, but when a terrible epidemic demanded a double supply for the purpose of cleansing the streets. So large a deficit rendered it impossible to flood the gutters or water the streets, while the refuse lay stagnant in the sewers for want of current; the fountains and hydrants were without water during the summer, and Montmartre, Belleville, and Menilmontant were short of water all the season. The terror caused by the presence of the cholera under such circumstances gave the necessary impetus for insuring the increased supply of water to the capital.

Moreover, the number of the inhabitants of Paris is not only increasing every day, but new parks, gardens, and squares are growing up, and will require more water; lastly, there are 3,000 hydrants in the streets which are closed during the summer for want of water.

The quantity of water required for the future supply of Paris is set down at 420,000 tons per day, and the works now under hand are intended to bring it up to that figure. Of this total, 250,000 tons are required for the public service, watering roads, streets, paths, and grass, flooding gutters, sewers, etc., for which purpose no special quality of water is required. Of the remaining 170,000 tons, 40,000 are required for manufactories, and this may be taken from the Seine and the Marne, which falls into the former just above the city.

The 130,000 tons thus left for domestic use should be water having special qualities. The waters of the Ourq and of the Marne are too hard, and anything but agreeable to the palate; the water of the Seine is frequently muddy, besides being too warm in summer and too cold in winter. Spring water alone furnishes the necessary conditions, and this is the reason for bringing the waters of the Dhuis and the Vaune to Paris.

The Dhuis water arrives in the reservoir of Menilmontant at Paris at an altitude of 354 ft., and a portion of it is then pumped up into the reservoir at Belleville, 436 ft. high, for the supply of the high grounds of Montmartre, Belleville, and Menilmontant. The Vaune waters will be received in large reservoirs having an altitude of 244 ft.

Of the 59,000 houses and manufacturing establishments now existing in Paris, about 26,500 pay for water laid on to the premises, leaving 22,500 to be so supplied. The former consume at present 80,000 tons. When all are supplied, taking two millions of inhabitants, which the city is fast approaching, as a basis, each house, on an average, will receive more than 17 gallons of water per diem, or 26 tons per annum, at an expense of 4s. a year, or less than 1 ton of filtered water purchased of the water carriers, as is still the practice in all the houses to which water is not yet laid on. Ten francs a month is, under the latter circumstances, a moderate sum for a family to pay for water.

Under these considerations of the present and future wants of Paris, the municipal authorities caused a careful examination to be made of the means of supply, the result of which was the choice of the source of the Vaune with its tributaries for the completion of the supply of the city. The Vaune is a small stream which takes its rise in the department of the Aube, at Fontvaune, so named from the source, near Estissac, on the edge of the chalky plains of Champagne, and about 8 miles from Troyes. Its direction is from east to west, and it receives seven tributary sources before it falls into the Yonne just above the town of Sens. One of the reasons why the choice fell upon the Vaune was the remarkable constancy of its stream. Its basin, which is equal to nearly a thousand square kilometres, is entirely formed in the white chalk, but the plateaux are crowned with tertiary strata, formed generally of red mud mixed with loose stones. The plateaux are broken up, and the chalky slopes are bare, as is usual in Champagne. The valley is large and flat, and composed of very wet, marshy

land. The water is remarkably limpid. The Dhuis was far from presenting such advantageous conditions. Its sources were originally invaded by torrents, and cost much labor to preserve.

All the sources of the valley of the Vaune have been purchased by the city of Paris. They amount in all to thirteen, and are all on the left bank of the stream. Besides the sources, the city had to buy the factories and establishments most injured by the taking of the water. The first source is that of Cerilly, or Bûne. It springs out of the ground at an altitude of 460 ft., and its waters are so limpid that the bottom is clearly seen in a deep gulf. The water of the other sources is of equally good quality. The altitudes of the nine sources vary from that already given to about 290 ft. The water of all these sources will have to be lifted by machinery into the main aqueduct.

It has already been stated that the water of the Seine is too warm in summer and too cold in winter; and water, when too cold, not only gives rise to interruption in the service by freezing in the pipes, but may be the cause of grave disorders and inconvenience. The experience of ten years has proved that the Arcueil has an average temperature of from 50 deg. to 54 deg.; during the great heats the Dhuis water arrives in Paris at a temperature of about 56 deg. The waters of the Vaune will arrive in Paris completely aerated by an aqueduct open to the air throughout an extent of about 90 miles.

The water of the Seine will eventually only be used for manufacturing purposes, the quantity of organic matter in that river being too large to render the water fit for domestic purposes.

The works of the aqueduct present many features of importance. In the first place, each of the upper sources has to be conveyed by means of a secondar aqueduct to the main one. Between Thiel and Malhortie the aqueduct is carried on arches over the valley. From the latter place the line follows the chalky slopes of the right bank of the stream, passes to the right of the town of Sens, and enters the valley of the Yonne, skirting its right flank to a little below a place called Pont-sur-Yonne. Thence it is carried across the valley by means of a great siphon, and is continued to Moret, on the slopes of the Seine, without any serious difficulties. It then crosses the valley of the Loing, and enters the forest of Fontainebleau.

Here the most serious difficulties arise, on account of the composition of the soil, which is formed of sand, lying higher than the plateau composed of the argillaceous millstone which stretches thence to Paris. It was necessary to cut deep trenches and to form tunnels, one of which is very long; fortunately, however, there is no water here, or the work would have been almost impossible. After quitting the forest the aqueduct starts at the sandy hills, crosses the valley of Ecolle, and at Champteuil touches the argillaceous plateau, which it follows till it reaches Paris. Passing over the rivers Essonne and Orge, the aqueduct enters the valley of the Bièvre, and reaches Paris at the plateau of Montrouge, near the Orleans road, after a course of 89 miles.

The aqueduct is calculated to yield at least 258 gallons per second, its maximum being 324 gallons. The cost of the work will be about £1,160,000.

The reservoir is constructed in two stages; one of these, with an average depth of 11 ft. 8 in. of water, will contain about 123,000 tons, with a maximum altitude 262 ft.; the second, with a depth of 18 ft., will hold 182,000 tons, with a maximum altitude of 248 ft. Four conduits will carry the water from the aqueduct; two of these, 32 in. in diameter, will supply the upper, and the other two, 43 in. in diameter, the lower reservoir. The cost of this double reservoir is stated to be about £200,000. The whole cost, therefore, of bringing the waters of the Vaune to the edge of Paris ready to be turned into the mains will be about £1,360,000, and it would be difficult to find an instance of money better employed.

Wire Cable Towage.—The "Société Centrale de Touage," which has its seat in Brussels, has lately made a satisfactory experiment as to the practicability of introducing wire cable towage on the Rhine. The great advantage of the system is the saving of coals effected by the use of the cable, which is calculated at 75 per cent., the great objection to its general adoption being the difficulty of moving the vessels thus towed, out of the way of other ships.

TRUE BASIS FOR THE CONSTRUCTION OF HEAVY ARTILLERY.

By LYNALL THOMAS.

The essential point to be considered in the construction of a cannon (especially a rifled cannon firing cylindrical shot and heavy charges of powder) is the general effect produced in the gun by different charges.

In the opening chapter of Col. Boxer's well-known Treatise on Artillery, the author has pertinently remarked that "the force and effect obtained from gunpowder is the foundation of all other particulars relating to gunnery." A true knowledge of its force and action is therefore indispensably necessary, since without it no gun can possibly be constructed on sound principles.

More than ten years have passed since I first attempted to introduce a new system (based upon actual experiment) for heavy artillery.

It was entirely opposed to all existing theories or received opinions on the subject; and although at no period have so many gunnery experiments been carried on as during the interval referred to, none of the results of these experiments have tended to cast any doubt upon the truthfulness of the views I first put forward.

I am induced again to bring forward the subject, chiefly with the view of defining more clearly the principles upon which this system is based, and in what respect it materially differs from the system or theory which has hitherto been accepted as the true one.

The last-named theory was first promulgated about a century ago by Robins (who may be styled the father of modern gunnery, as he was the first who elevated it to the rank of a science), and is based chiefly upon experiments made (on the force and action of gunpowder) with a musket and small quantities of powder. It teaches as follows:—That "gunpowder fired in any space acts nearly in the same manner as a quantity of air would do which was condensed a thousand times more than the common air we breathe, and which in that condensed state filled the same space that was taken up by the unfired powder." (Robins's "Tracts on Gunnery," Prop. i. p. 219, Hutton's edition, London, 1805.)

Upon the above most untenable proposition the whole theory of modern gunnery is based!

In all works of gunnery therefore we find it assumed:—

1. That the whole of the charge of powder is converted into an elastic fluid capable of exerting a finite pressure only, the limit of which it attains before the projectile is sensibly moved from its place. (Dr. Hutton gives it as his opinion that the combustion of the charge is gradual; but in his various *formulæ* it is not supposed to be so.)

2. That the fluid exerts an equal pressure, estimated at so many atmospheres (but as nearly every experimentalist has assigned a different value to the initial pressure of fired gunpowder, it is impossible to say exactly how many), upon the shot and upon the sides of the chamber or portion of the bore of the gun which contains the charge. (This virtually supposes that the fluid evolved from the fired powder is *contained* in the chamber of the gun.)

3. That the value of the initial pressure is constant in guns of every calibre, and with any quantity of powder.

4. That the pressure upon the shot in its passage out of the gun is in the inverse ratio of the spaces occupied by the fluid (assuming thereby that the temperature of the fluid remains always the same).

5. That the movement of the shot through the first spaces is a slow one, and that the larger the calibre of the gun (the weight of the powder and projectile being proportional) the slower is the movement.

6. That the strain upon the gun is not affected by the weight of the projectile; and when in practice this is found not to be the case, the most absurd reasons are assigned for it; and the same may be said with regard to the observed variations in the initial pressure of different quantities of powder. The latter has even been attributed to a variation in the length of the gun. ("Hutton's Tracts," vol. iii. p. 296.)

7. That the pressure being constant in value, shot of every calibre fired with proportional charges of powder must pass through equal spaces (in calibre) before

they can acquire a given velocity. (According to this law, therefore, guns of all calibres ought to be of the same relative proportions (in calibres). — "Hutton's Tracts," vol. iii. p. 313.)

It is almost needless to remark that the above (which may be called the atmospheric pressure) theory is entirely at variance with experiment, a fact which renders all the more remarkable the tenacity with which it has been adhered to.

It was this discrepancy between theory and experiment which first led me to carry out a series of experiments with the view of discovering, if possible, the cause of it.

These experiments soon removed all doubt as to the nature of the action of fired gunpowder. It was clearly *impulsive*, or *percussive*, acting upon the shot and sides of the containing chamber in the manner of a blow, starting off the former, at once, with a considerable velocity, proportional, in a certain ratio, to the quantity of powder employed.

This simple fact at once destroyed the value of nearly every formula in use; and it is strange that whilst several well-known writers appear to have casually remarked the percussive nature of fired powder under certain circumstances (as in the bursting of guns), no one seems to have considered that it in any way affected, or to have applied it to, the action of an ordinary charge of powder.

Several scientific men of eminence have attempted, from time to time, to determine the value of the force of gunpowder, but with apparently very little success, since they have variously estimated it at from 1,000 to as many as 100,000 atmospheres; in fact it was found to vary with the different conditions under which the experiments were made. It will be easily seen, therefore, how impossible it is to construct a gun of correct proportions, or to determine the proper charge to be used with it, by the old theory. Consequently, up to the time when rifled ordnance were first introduced, all guns were constructed of the same relative proportions, those of a 68-pounder being similar to those of a 9-pounder gun.

But although it may be said to be impossible to assign even an approximate value to the force of gunpowder, it is not difficult to ascertain the *relative* value of the strain produced by different charges, fired under similar conditions, in guns of different calibres; and for practical purposes this is all that is required to be known.

The results of my numerous experiments have enabled me to arrive at the following conclusions with respect to the action of gunpowder and its effect upon the gun:—

1. That the whole charge of powder does not undergo complete conversion into gas before the shot is moved.

This important fact will not be disputed, as it has been already recognized by nearly every writer on the subject. Dr. Hutton has repeatedly assigned, as one of the causes of the discrepancies between the results of theory and those of experiment, the erroneous assumption that the whole charge was instantaneously fired. It will not be necessary for me to support this point by any further argument; some years ago I seized the opportunity of so doing, and my views upon the subject have since been fully appreciated by every artillerist.

2. The second proposition that is maintained in the treatise is, that the first action of the powder upon the shot is in the nature of an impulse of greater or less magnitude, dependent upon the quantity and the quality of the powder used, as well as on the position of the point from which the charge is fired.

That portion of the charge which has been converted into gas, impinges with a terrific velocity upon the shot, and begins to expel it before the whole of the charge is completely consumed or its force fully developed.

The action of this portion of the powder has been above denominated the first or initial action; and these words will be used in this sense throughout the rest of the treatise. The velocity imparted to the shot by this portion of the charge may be properly called the initial velocity.

These words are generally used to signify that velocity which the projectile has when it issues from the muzzle of the gun; here, however, they are used to denote that velocity which the shot has in the very beginning of the motion, viz., that with which it leaves its position of rest.

The word impulse is used in its popular and natural sense, to denote a force which generates a finite velocity in an indefinitely short period of time. In fact, the whole time that elapses between the ignition of the charge and the expulsion of the

shot from the piece, is scarcely sensible; yet it can be subdivided into intervals that bear some ratio to one another. In one of these intervals a portion of the charge has been fired, and a certain velocity has been simultaneously imparted to the shot; in the other interval the remaining part of the powder has been consumed, and the shot has been moved through the piece. The initial action of fired gunpowder is thus said to be impulsive, because it produces motion in the projectile before the whole charge has been completely converted into gas. The position of the vent is a matter of some importance. If a charge be ignited at the extremity nearest the shot, the violence of its initial action upon the shot will be diminished; but its action in the direction of the breach will be considerably increased.

There is nothing in this theory at variance with observed facts; on the contrary, it affords a clear explanation of many otherwise inexplicable results, and furnishes a simple and intelligible law for the construction and use of ordnance, whilst the atmospheric pressure theory, being altogether irreconcilable with facts, abounds consequently in those paradoxes occasionally quoted by officials with a kind of triumphant air, as affording convincing proof of the utter hopelessness of any attempt to find a law for the action and force of different charges of powder fired under various conditions.

Equal charges, fired under similar conditions from guns of a given calibre, invariably produce the same results. When, therefore, in practice, results are occasionally obtained which cannot be reconciled with the atmospheric-pressure theory, it is clear that the theory itself is faulty; since it is not probable that a charge should act in an eccentric manner on particular occasions without some cause being assignable for it.

The errors which are traceable throughout the atmospheric-pressure theory may be likened to so many rotten strands in an otherwise sound rope, which render necessary its complete reconstruction before proper reliance can be placed upon it.

We now proceed to show how these conclusions may be employed in calculating the strain exerted on the gun.

In the first place it must be observed that whilst the shot is traversing the initial space, the rest of the charge is undergoing complete conversion into gas; and when such conversion has taken place, the gas rushes forth in the direction of the axis of the bore. A considerable portion of this gas is driven into, or, more properly, condensed in that space that has been just vacated by the shot; and at this important instant the gun is called upon to sustain the greatest possible strain that is exerted upon it. If the gun be of sufficient strength and thickness to endure the disruptive power of the charge, the chief effect of the intense pressure will be directed towards the removal of the shot.

From the above explanation it will be seen that, in order to be able to calculate the different degrees of tension for different guns, we must first endeavor to investigate the mathematical relation subsisting between the initial velocity, the weight of the shot and of the charge, and the diameter of the bore. As soon as we have determined in what manner the velocity depends upon these known quantities, we shall be able to express in terms of them the volumes into which the gas is condensed; and then it will be seen that the relative strains exerted upon different pieces can by an easy process of mathematical reasoning be expressed as algebraical fractions of certain known quantities.

Having arrived at the above conclusions, my next object was to ascertain, by a series of experiments, in what way the initial velocity of the shot varied with a variation either of its own weight, or of that of the powder employed, or of the weight of both of these. For this purpose I caused to be constructed a series of cylindrical chambers, of different diameters and depths; these were sunk in blocks of the best metal, and when fired were filled with the powder generally used. The shot was spherical in shape, and was placed gently and evenly on the top of the chamber. The vertical distances traversed by them were in every case accurately measured by means that I need not proceed to explain. I observed that the velocity of projection was entirely due to the initial action of the charge, and was in no way altered by the subsequent explosion of that portion of the powder which was fired after the first movement of the shot.

In order to convince myself of this all-important fact, I caused the shot to be

raised by a hair's breadth above the top of the chamber; and when in that position the fired charge produced a motion that was barely sensible, and when the shot was elevated by something less than $\frac{1}{8}$ in., no movement of any kind was observed on the charge being fired.

These experiments showed that the velocity initially imparted to the shot was not increased by the blast of the powder it had left behind; and therefore the vertical spaces described were then due to the velocities of projection.

It is unnecessary for me to give my experiments in detail; in fact, the limits of this short pamphlet forbid me so doing. I need only state that after laboring for several years, and varying in every possible way the relative weights and dimensions of the powder, the gun, and the shot, as well as the circumstances under which they were fired, I found the following laws to hold invariably:

1. That when shot of the same weight and size were subjected to the action of different quantities of powder, fired in chambers of the same diameter, the initial velocities communicated to them were directly as the square roots of the weights of the charges employed.

2. That when shot of different weights were placed upon the same chamber, filled with the same quantity of powder, the initial velocities were inversely as the square roots of the weights of the shot.

3. That when shot of different weights were subjected to the action of different charges of powder, fired in chambers of different depth, but of the same diameter, the initial velocities were directly as the square root of the weight of the powder, and inversely as the square root of the weight of the shot.

4. *That when the diameter of the chamber was increased, the initial velocity was increased (with proportional charges) in the ratio of the square root of the diameter.**

The above laws are based upon the results of innumerable experiments. At the time when I first began to examine the initial effect of gunpowder, I had no particular theory of my own to uphold, but was anxious to investigate in a truth-seeking manner the cause of those wide and seemingly unaccountable discrepancies between the conclusions derived from Robins's theory and the results of experiment. I was, in the beginning of my labors, rewarded with the discovery of (what I had previously taken to be) the real nature of the action of the fired gunpowder. I do not lay any great stress upon the fact that the charge is gradually ignited, as this has been affirmed by every writer on gunnery; but it is the application of this principle, for the purpose of investigating the strain exerted upon the gun, that seems to have escaped Hutton, Rumford, and others. That the initial action of gunpowder is impulsive, or, in more intelligible language, that the shot is sensibly moved before the whole charge is inflamed, is the great proposition that lies at the foundation of the present theory.

After I had gone through a short course of experiments, I was induced, by the apparent invariable uniformity of the action of gunpowder, to frame a few laws for the purpose of establishing formulæ upon which subsequent calculations might be based. I was enabled to test and to rectify the laws that I had first formed, until ultimately I arrived at those very expressions which theoretical investigations declare to be founded on truth.

I now proceed to investigate certain algebraical expressions for the pressure and tension, founded upon the above laws. Let L denote the length of the shot (*suppose cylindrical*),

d denote the diameter of the bore,
W denote the weight of shot,
L' denote the length of cartridge,
W' denote the weight of cartridge,

the point of ignition being the same in each gun.

Now by the fourth law* the initial velocity varies as

$$\sqrt{\frac{W'd}{W}}$$

And as we purpose to calculate the relative strain only, we may take this to represent the initial velocity.

* All who know any thing of the action of gunpowder are aware that the effect produced by the combustion of a given quantity, when spread over a large surface or formed into a long train, is very different from that which is produced by the combustion of the same quantity placed in a heap, or in as small a compass as possible. It is not difficult, therefore, to imagine that the initial effect produced on projectiles by powder confined in a different form may be different.

* By the first law, if the length of the cartridge be varied, the initial velocity varies as $\sqrt{W'}$; by the second law, if the weight of the shot be varied, the initial velocity varies as $\sqrt{W}$; and by the third law, if both these quantities be varied, the initial velocity varies as $\sqrt{\frac{W'}{W}}$.

The volume that is vacated by the shot may be written

$$\sqrt{\frac{W'd}{W}} \times d^2.$$

Into this volume a certain portion of the gaseous fluid is condensed. This portion varies as $L'd^2$, i. e. as W'. Thus the pressure that is impressed upon that part of the piece that has been initially traversed by the shot, will be as

$$\frac{W'}{\sqrt{\frac{W'd}{W}} \times d^2}, \quad \text{i. e. as} \quad \sqrt{\frac{WW'}{d^5}}.$$

The degree of tension* of the gun-metal will therefore be expressed by

$$\sqrt{\frac{WW'}{d^3}}.$$

This formula was found to accord in every way with the results of my experiments.

It measures the disruptive tendency of the charge, and will enable us to show how the thickness of the metal must be increased in guns of different calibres, the proper quantity of metal having been acquired in the first instance for a gun of given calibre, as in the case of the 7-inch gun for instance.

It would appear, then, that by sufficiently increasing the thickness of the piece it would be rendered strong enough to support the charge that it was intended to carry, and that the danger of its bursting would be entirely obviated. This, however, is not true; at least it must be received with some caution.

Whilst I was engaged in making my experiments, my attention was constantly being directed to the fact that the interior surface of the piece generally exhibited signs of great distress, whilst the exterior surface appeared to be as safe and as firm as ever. In fact, I frequently found that a gun might be burst by a charge that it had frequently sustained, but which by having been repeated had encroached upon the inner surface so as to undermine completely the original strength of the piece.

* It is known that if a gas be contained in a cylinder, the tension at any point in the curved surface of the cylinder depends upon the radius of the cylinder as well as upon the pressure of the gas. And in fact if p denote the pressure of the gas and r the radius of the cylinder, the tensional force is pr. In the above we have taken it to be pd; this will make no difference, as we are concerned only with the relative magnitudes of the different quantities.

The portion of the bore that appeared to have suffered more severely from the action of the powder, was that immediately about the base of the shot; in fact that part through which the shot had initially moved, and which, from what has been said before, was called upon to endure the greatest bursting power of the gas.

The following might be offered as an explanation of this fact:

The pressure which the inflamed charge exerts upon the surface of the bore produces a strain throughout the thickness of the metal. This strain is transverse to the axis of the bore; and its effect would be to sever the cylinder along one or more of its generating lines. Should this disruptive force be held in check by the thickness and strength of the gun-metal, no sign of any stress will be discernible upon the exterior of the gun. But with the interior surface the case will be different, since the gas in its efforts to escape through the thickness of the piece has been grinding that layer of the metal (in immediate contact with it) against the layer immediately above.

Thus it would seem that the corroding effect, as it may be termed, of the charge upon the inner surface of the gun depends upon the intensity of the pressure.

Now this pressure has been before shown to equal

$$\sqrt{\frac{WW'}{d^5}}.$$

If we put for W and W' their proportional values Ld^2 and $L'd^2$ respectively, the pressure is made to depend upon

$$\sqrt{\frac{LL'}{d}}.$$

It will be seen on reference to the expression for the tension that the weight of the shot considerably affects the strain upon the gun. And no one who has ever made any experiments in gunnery doubts that such is the case. This point has considerably perplexed artillerists who have been taught to place implicit faith in the well-known assertion of Robins, that the strain upon the gun is the same whether a ball be fired or not.

The great mistake committed by artillerists of the old school was in considering the bursting effect of the gas to be simply a statical force. In all their treatises it is assumed that the whole charge, having

been instantaneously converted into gas, pressed with equal intensity in every direction. Had such been the case the shot would have scarcely moved whenever the gun burst, the gas having escaped from the piece before it had had any time to generate velocity in the shot. Had the charge been instantaneously inflamed, the impulsive strain exerted against the sides of the chamber would undoubtedly have been of the same intensity, whether there was any thing to obstruct the subsequent passage of the gas or not. In this case the powder would have exerted its full effect upon the gun before it had time to relieve itself by expansion through the bore.

If, then, we take into our consideration the effect of the removal of the shot before the total conversion of the charge, we are led by a well-connected chain of reasoning to determine the manner in which the rest of the charge rushes towards the space that has been traversed by the shot. This space is of course already filled with the gas that was generated in the very beginning of the explosion; and the moving power of the powder when wholly ignited condenses a considerable portion of the gaseous volume into this, comparatively speaking, vacant chamber. The quantity of gas so condensed has been above taken to vary as $L'd^2$, and the use of this expression involves no assumption whatever. For if I stood solely upon the results of my experiments I should be justified in counting it as such; and theoretical considerations affirm the truthfulness of such an expression. The volume that would be driven forward in any time evidently varies as d^2, whatever be the length of the charge; and since the whole body of the gas is moving in the direction of the axis of the tube, the intensity of the condensing force varies as L′, the length of the charge.

The three formulæ that have been obtained by the principles enunciated in this pamphlet may be briefly stated as follows:

The initial velocity is given by $\sqrt{\frac{W'd}{W}}$, the tension or the bursting effect by $\sqrt{\frac{WW'}{d^3}}$, and the corroding effect of the pressure by $\sqrt{\frac{LL'}{d}}$.

The charges are supposed to be fired under the same conditions in each gun.

These formulæ will hold good whatever the quality of the powder used with, or metal employed in the manufacture of, the gun, unless, indeed (which is scarcely within the limits of possibility), a metal of an imperishable nature could be discovered wherewith to line the interior of the gun.

If the foregoing is (as I firmly believe it to be) correct, it is a most important fact, since (contrary to general opinion, which supposes that by doubling, say, a charge of powder the strain on the gun is doubled) it shows that to double the strain on a gun the *weight of the projectile* as well as the quantity of powder must be doubled.

Now, as the striking effect of shot of given form and calibre depends (at moderate distances) on the force with which they are projected more than upon their own weight, and if (as appears to be the case) the weight of the shot tends so considerably to increase the strain of the gun, a reduction in the weight of the shot and corresponding increase in the powder-charge might in most cases be attended with better general results. By proportioning the charge to the shot in such a manner that the product of the proportions of both shall never exceed a given quantity, the effect produced on the gun by the different relative quantities would be nearly the same. One of the great advantages attending the use of rifled cannon is the power of employing either a heavier charge and lighter projectile or the contrary, as occasion may require.

[TO BE CONTINUED.]

The United States war sloop Yantick has been appointed by the American Government to make the soundings for the West Indian submarine cables from Jamaica to Porto Rico, St. Thomas, and Barbadoes. The British Admiralty have also ordered a vessel to continue the soundings from Barbadoes to Trinidad and Demerara. The Yantick is being fitted with sounding gear at the Navy Yard, Brooklyn, and will sail on the 1st of January, under the command of Capt. Irwin, United States Navy, by whom the soundings between Jamaica and Panama have already been made in the Gettysburg.

THE CLIFTON BRIDGE, NIAGARA.

By SAMUEL KEEFER, Engineer.

From "Engineering."

This bridge has been open to the public just one year, and the result has been most satisfactory. It has economized the time of transient visitors, and has been a great convenience to those who remain for any length of time; while to the stockholders it has yielded a large percentage on their outlay.

A fearful storm visited this part of the country in the latter part of November last, which extended, also, with more or less severity, over a great portion of this Northern continent, making its power felt by upsetting an iron bridge lately erected in Ohio, and blowing a whole train off the track on the New York and Harlem Railway, leaving nothing but the engine standing on the rails. Judging from its effects, it appears to have been quite as strong as the imaginary tempest referred to at page 301, vol. vii., of your journal, against which provision was made in the construction of the bridge.

My attention was first called to its effect on this bridge by a short paragraph in a Buffalo paper; and as soon as my time permitted I paid a visit to it to learn from the parties in charge the true nature and extent of the disturbance caused by the storm; and I trust that the following facts, gathered from their statements, may be considered of sufficient interest to find a place in your valuable journal.* Your readers, who have seen the account and illustrations of this work, which appeared in vol. vii. of "Engineering," pp. 287, 290, 300, and 301, will understand from these, and will fully appreciate, the endurance of so light a structure under such a very severe test.

The storm occurred on the 17th November, and raged 12 hours, from 9 o'clock in the morning to 9 o'clock in the evening. It gathered up its forces in the long sweep of Lake Erie, and struck the bridge nearly square upon its beam—the course being S. S. W., bearing hardest on the Canadian shore. It gradually increased in intensity until 1 o'clock, when there came a shock which, it is supposed, moved the two anchor stones on the S. W. quarter, to which the longest guys in that direction were attached, one weighing 9 tons, and the other 32 tons, pulling them from their beds, and rolling them over 10 ft. nearer to the bridge. This power, be it remembered, was exerted by a small wire rope, only $\frac{5}{8}$ in. in diameter, and of an ultimate theoretical strength of only 10 tons. By the loosening of these two ropes, and of another on the S. E. quarter, in a similar manner, more play was given, and the wind had more effect upon the platform; but from 1 o'clock until 4, the disturbance was not so great but that foot passengers and carriages continued to cross, although with much difficulty in making head against the wind. During this time the wind acted by impulses. It would lull for a time, and then return with greater fury than ever. At 4 o'clock it had reached its greatest strength, when the longest guy on the S. E. quarter gave way at the fastening, and then followed, in quick succession, first all the guys on the S. E., and then all the guys on the S. W. quarter, up to within 200 ft. of the land.

Altogether, the platform was held in place by 58 guys—30 on the upper or windward side, and 28 on the lower side. 21 of those on the windward side gave way, including the three before mentioned as having dragged their anchors, leaving only 9 still holding on that side, and extending out, as before stated, 200 ft. from either end. As the guys on the leeward were slackened by the yielding of those on the windward side, none of them were broken. The middle of the bridge immediately canted over about 3 ft. to leeward, while, the platform being fixed at both ends, there was accordingly that much twist in the framework. The canting of the bridge exposed it more directly to the action of the wind, and thereby caused the cables to swerve so much more from their true positions. The cradle form of the system accounts for this disturbance of the level, for as the one to windward rises, the other, being linked to it through the platform, must necessarily fall, and thus throw the bridge so much out of level.

* It is from an intelligent consideration of such facts as these that an engineer learns how to build.

So it will be seen that, after the partial yielding of the guys, the platform was exposed directly to the action of two disturbing forces—first, the weight of the guys on the leeward side, and second, the horizontal pressure of the wind. These forces were met by two others that belong to the bridge—first, the inherent strength and stiffness—the whalebone toughness of the framed roadway—and, second, the weight and strength of the cables, their weight coming in play the moment they were swayed from their normal positions. The weight of the leeward guys alone was sufficient to depress the lower side 10 in., and the guys and the power of the wind together canted it about 3 ft., as before stated.

The vertical undulations of the roadway, after it had been exposed in this manner to the full fury of the wind, did not at any time exceed 18 in. This, for so long a span, and so light a structure, must be considered a very moderate departure from the true curve. It must be directly attributed to the beneficial effect of the small hollow studs introduced between the cables and the roadway at intervals of every 50 ft. from the centre, while at the centre the cables themselves bear directly upon the platform. By this arrangement the weight of the central portion of the cables for 400 ft. becomes an insistent weight to keep the bridge from moving; and the cables themselves, weighing 81 tons, cannot easily be thrown into an undulating motion, more especially as they are checked, each of them by four bridle stays.

At four o'clock the gates were closed against carriages, and were not opened again until nine, when the storm had completely subsided. As soon as it was over, the platform returned at once to within 10 in. of its horizontal position at the centre, and although the bridge was out of line, carriages could cross it again as usual.

The framework of the roadway did not suffer the slightest injury during the storm, and not a single timber, plank, or bolt was broken or displaced. Moreover, strange as it may seem, not a single wire rope of any kind about the bridge was broken (a fact much to the credit of the makers); it was only thin fastenings that failed. Owing to the bad quality of the iron, some of the ring bolts in the chord above, and some in the rocks below, were broken, while in other cases the rocks moved, or, being loosely stratified, treacherously yielded to the strain. Nor did any socket fail. The only instance of a rope giving way in a socket, was in one of the bridle stays, and this, upon examination, proved to be unskilfully made. All repairs were promptly made, with stronger fastenings to the guys, and I found the bridge in perfect line, in good condition, and, if anything, more secure than ever against accident. During the worst of the storm the towers stood as firm as a rock. The foreman in charge ascended to the top in the afternoon, and could not perceive the slightest vibration.

Altogether, I have reason to be proud of the manner in which this bridge withstood the trial, and I may remark that the fact of its having escaped with so little injury has inspired more confidence in those who are in the daily habit of using it. It suffered much less than Telford's Menai bridge during a similar storm some years since. On that occasion, it will be remembered that the platform was broken up, and part of it carried away.

I may now point out three features in this bridge, which, in conjunction with the guys, materially contributed to its safety. First, the hollow iron studs (gas-pipe) between the cables and roadway at the centre of the bridge, causing them to move together as one. Secondly, the bridle stays serving to check the vertical vibrations in the cables; and thirdly, the rolled iron bars fish-plated together under the lower chord of the side truss, forming, as it were, a continuous chain from end to end of the platform. Without this iron chain the wooden chord would have been pulled to pieces. In order to check the action of the wind on the centre of the bridge, two small steel wire ropes are to be tightly strained from cliff to cliff, crossing each other at nearly right angles under the centre of the bridge. When under strain, the bridge is to be attached to them in such a manner as to give it an initial power of 10 tons to meet the force of the wind, the moment it begins to disturb the condition of repose. Up to that moment the strain is on the rope, not on the bridge, and after that there is a power of 50 tons to keep the bridge from vibrating more than 10 in., while the vertical play of 3 ft. due to changes of temperature, produces no sensible effect upon the braces.

INTERESTING ESTIMATES ABOUT THE SUEZ CANAL.

From "The Financial Chronicle."

In France, the "Messageries Imperiales" are adapting some of their fine steamers for the canal. A number of light-draught steamers are building in England for a similar use, and docks and warehouses have been secured by the Russian authorities at Port Said for the use of the Great Commercial Company of Odessa, whose vessels will ply between that port and the East. The powerful and wealthy Austrian Lloyd has offered to carry free, samples of the national products, with a view to improving and extending the trade of Austria in the Indian seas; and the Italian Government has urged the shipowners of that country to prepare to profit by the opening of the canal. A steamship line is organizing in Spain to ply between Barcelona and the Philippine Islands; and in this country the Oriental Steam Navigation Company will soon establish direct communication with China, India, and the Mediterranean ports. As a general summary of the commercial movement, M. de Lesseps estimates the tonnage of Liverpool at 6,000,000, and the trade through the Dardanelles 6,000,000, and claims that the traffic of the canal will be 6,000,000, affording from the tonnage alone an annual return of $12,000,000.

It is also claimed that the opening of the canal will favorably affect the commerce of the United States with the East. For the fiscal year ending June 30, 1867, our direct trade with the principal countries of the East, viz., Dutch East Indies, British East Indies, Australia, Philippine Islands, the South Pacific Islands, and China, was, total exports $14,606,809, total imports $24,780,097.

During the same period the total of exports to southern Europe, the Mediterranean, and the East Indies, was $71,780,203, and of imports, $65,394,796, in all $137,147,999; from which it will appear that $\frac{1}{6}$ of the foreign commerce of the United States was transacted with the countries named. How much of this trade will flow through the new channel, remains to be seen. The canal undoubtedly shortens the average distance between our Atlantic ports and the East, as will appear from the following table of comparative distances from New York and Port Royal to the principal ports of Australia and Asia, via Gibraltar and Suez on the one hand, and San Francisco and the Pacific on the other, measured in nautical miles, with the exception of the distance overland to the Pacific coast:

	From New York via Gibraltar and Suez.	From Port Royal via Gibraltar and Suez.	From New York via San Francisco & Pacific R. R.
Melbourne.....	13,200	13,700	10,300
Shanghai......	12,500	13,000	8,850
Hong Kong....	11,700	11,100	9,300
Manilla.......	11,600	12,100	9,600
Singapore......	10,300	10,800	10,600
Batavia........	10,500	11,000	11,000
Penang........	9,950	10,450	11,000
Calcutta.......	9,700	10,200	12,150
Ceylon.........	8,750	9,250	12,200

At a recent meeting of the Ethnological Society some photographs of the great megalithic monuments in Wiltshire were exhibited. We understand that a scheme is now in progress to obtain funds for the purpose of procuring a series of photographic representations of the megalithic monuments found in England and France, and, if possible, in Europe and Algeria. Such a series, in which the compass-bearings and accurate dimensions would be given, would be invaluable to the student in archæology. "Nature" says that any interested in the work who wish to know more of the details are requested to communicate with the Librarian, Royal Geographical Society, 15, Whitehall-place.—*The Engineer.*

Experienced engineers have stated that the cost of taking the London sewage to Sea Reach would greatly exceed the total cost of the metropolitan system of main drainage, and that the area requisite to utilize the sewage would not be less than 70,000 acres. We believe it appears in the evidence attached to Mr. Rawlinson's report, that, as compared with guano at £11 a ton, the annual value of the London sewage is not less than £1,000,000.—*The Engineer.*

IRON AND STEEL NOTES.

Iron Ore—Sources of Supply.—The iron interest in the West is increasing with greater rapidity than almost any other. Furnaces and rolling mills are being erected in Michigan, Wisconsin, Illinois, Indiana, Ohio, Kentucky, and Missouri. The demand for iron ore is rapidly increasing, and many of the old as well as most of the new works (even to a distance of 1,000 miles by water) are looking to Missouri for a supply.

The Iron Mountain and South Pacific Railroads are the only ones on which any considerable beds of iron ore are known to exist, accessible to this market. The present demand from the Iron Mountain is greater than its means of supply. The seven furnaces at Carondelet, when all in operation, will require not less than 200,000 tons of iron ore per annum. The contract now existing for iron ore, to be shipped to various points on the Ohio River, as far as Pittsburg, and to the interior of Indiana, will require nearly as much more—making an aggregate of 400,000 tons annually.

It is not within the capacity of Iron Mountain, Pilot Knob, and the Iron Mountain Railroad to furnish this supply. The demand for Missouri ore, present and prospective, is equal to the full capacity of tonnage on both the Iron Mountain and the South Pacific Railroads, and with rates the same as charged on the Iron Mountain for the same distance, if there were no difference in the quality of the ores, capital will be attracted to develop the iron in the new fields on the South Pacific. But as it is known among iron men that the red ores of the Southwest are more economical for all commercial purposes than the specular ores of Iron Mountain, or Lake Superior, or the hematites of Tennessee, it seems to us that the most inviting field for the investment of capital in the business of mining ores, at present, is in iron mines contiguous to the South Pacific Railroad. These mines are few in number, but so far as developed promise to be of the most extensive and permanent character. The ores yield more in the furnace, with the same amount of fuel, than any specular ores above named, and the product is equal in quality and for many purposes better than any other ores that can compete with them.

The ores of the Southwest are first met at Cuba, Crawford county, where two mines have been partially developed; next at St. James, where they have been worked very successfully for more than 40 years—and next in the vicinity of Rolla. In several of the beds the ore has been uncovered *in mass*, and specimens shown us from each, justify the conclusion that these deposits have been thrown up while in a liquid state, and thus cooled and solidified—giving the best possible guaranty of their inexhaustible character. In some of the Southwest mines the ore exists in boulders and detached pieces, in some instances running in lodes and veins.

The extension of the Pacific track to the river will greatly reduce the cost of transfer, and give a new impetus to the mining and shipping of the Southwest ores.—*St. Louis Journal of Commerce.*

The Terre-Noire Ironworks.—To those of our readers who have paid careful attention to the state and progress of iron and steel manufacture on the Continent, and particularly in France, the name of the Compagnie des Fonderies et Forges de Terre-noire, la Voulte et Besseges, will be well known and quite familiar, but to the generality of the British public and of engineers in this country and in America, the Terre-noire Company is less known than it deserves. As indicated by the lengthy title of this concern, the works are situated in three different localities, and they are managed from one head office at Lyons. The three separate works are devoted to different branches of iron manufacture, but the principal and most important works of this company are the steelworks at Terre-noire. These works were amongst the first licensed under Mr. Bessemer's patents in France, and have at present the largest production of Bessemer steel in that country. At the same time the Terre-noire Company are the most important licensees of Messrs. Martin in France, for the manufacture of Siemens-Martin steel, which is carried on very successfully and on a large scale at the Terre-noire steelworks.

The principal articles made at Terre-noire are steel rails and steel boiler plates. The raw material is produced on the spot in the blast furnaces of the Terre-noire Company, and from ores of such purity that the pig-iron can be regularly sent direct from the blast furnaces into the converters. This is the only instance known to us of Bessemer pig-iron smelted with coke being run direct from the blast furnace into the converter in regular practice, and it shows that the quality of the raw material must very nearly approach that of charcoal iron, which is usually converted into Bessemer steel direct from the blast furnaces in Sweden and in Styria. This superior quality of the raw material is unquestionably the first cause to which the Terre-noire Company is indebted as regards the quality of their steel, but the success is equally due to the care and attention with which this company has watched the progress of steel manufacture during the last period of transition, the intelligence and sagacity with which it has appropriated, and often even monopolized, every valuable improvement that has been brought out in this country or elsewhere, and the enterprising manner with which it has placed itself at the head of metallurgical progress in France. We may mention, for instance, that the Terre-noire Company has acquired a sole license for France from Mr. William Henderson for the manufacture of ferromanganese by his patent process, and having at the same time purchased the French patent of M. Prieger's invention for making alloys of iron and manganese, the Terre-noire Company is at present the only Bessemer steel works in France which employs rich artificial alloys of manganese for the manufacture of the softest kinds of Bessemer steel. Step by step, as valuable inventions are made in the branches of iron and steel manufacture, the Terre-noire Company has been trying, testing, and appropriating valuable improvements, and in an equal rate of progression it has spread the repute and the market for its products over the Continent, and even over England and America. There are steel plates from Terre-noire imported and purchased by some of the most celebrated boiler makers in this country, and the Terre-noire rails are the most formidable rivals of English Bessemer rails in the markets of Italy, Austria, and in America. The managing director of the Terre-noire Company is Mr. Alexander Jullien, a gentleman whose professional standing is well known to many scientific men in this country, and to whom we believe belongs the principal merit with regard to the important fact that in a very short space of

time the Terre-noire Company has risen from comparative insignificance to the position of a leading steel manufacturing concern in France.—*Engineering.*

Dephosphorization and Crystallization of Iron.—Experiments, instituted with a view to the dephosphorization of the iron from the Königshutte furnaces (Prussia), were made by the introduction of chloride of calcium into the blast furnace, on the theory that chloride of phosphorus might thereby be formed and volatilized. It was, however, found that the chlorine was liberated from its combination at entirely too low a temperature to effect any change. The results in this country, where fluoride of calcium has been substituted for the chloride, have been much more encouraging, and a decrease in the amount of phosphorus has really been effected thereby, some of it probably passing off in the form of a fluoride. The Prussian iron above alluded to contains 0.497 per cent. of phosphorus, and produces a highly cold-short and brittle Bessemer steel. Refining in a reverberatory furnace, by means of jets of air forced down upon the surface of the iron, was tried, but led to no favorable result. On puddling the iron and re-converting to cast-iron in a cupola, the percentage of phosphorus was reduced to 0.1. But this re-converted iron was found to be dearer than Cumberland iron delivered at the Bessemer steel works in Silesia, and so this process was abandoned of a necessity. It was also found that iron, when treated in this manner, loses silicon, thereby unfitting it for conversion into Bessemer steel.

A remarkable instance of the crystallization of metallic iron was noticed recently, during an examination by Mr. Crookes, of the Heaton or nitrate of soda process for the production of refined iron. After the subsidence of the violent action which ensues when the nitrate of soda is in contact with the molten metal, the converter, or lower portion of the apparatus, is detached, and, after a few minutes, the contents are turned out upon the floor in the form of a porous mass, weighing nearly three-fourths of a ton. A careful inspection of this mass of somewhat refined iron showed it to consist of minute cubical crystals, segregating or arranging themselves in feather-like groups. The crystals are said to be sharp and well-defined, and to present an exceedingly beautiful appearance. Such phenomena are by no means uncommon on the gradual cooling of masses of other metals, but the instances in which they have been noticed with regard to iron are very rare. During a recent visit to the smelting works of a mine in Wythe county, Virginia, we were able to procure exceedingly well-defined and quite large cubes of metallic lead, while the production of crystals of bismuth and some other metals, by a method of slow cooling, is described in most works on chemistry.—*American Exchange and Review.*

Anvils.—The face or table of anvils as at present made is often defective, having frequently hard and soft places after hardening, which face should be equally hard all over its surface, and the steel in some instances not being properly welded to the iron part or butt which forms the lower part, the anvil is thereby rendered unsound and not fit for use. Some improvements recently patented by Mr. J. N. Askham, of Sheffield, have for their object the removal of such defects, and consist in so making anvils that the face may be equally hard all over when finished, and in so casting or welding the butt to the head or upper table that the parts may be thoroughly amalgamated and the anvil made more durable at a less expense than hitherto.

Mr. Askham first prepares a model of the size and shape of the anvil to be produced. He then places it in a box, covers it with composition, and fills up the box with sand in the ordinary manner. After the model is removed and the sand perfectly dry (this being done in the usual way), he first pours in the molten steel to form the face or table, then, through the same aperture (after the steel on the table is sufficiently cool), he pours in a very mild molten steel, which flows over the table and gives the requisite toughness and solidity to the steel beck. After a proper time has elapsed, he pours in through another opening the iron or metal, which also runs upon the steel and forms the lower part or butt of the anvil, and a perfect amalgamation takes place between the iron and steel. The casting being complete, it is then finished in the ordinary manner for castings.

To harden the work, a large metal bosh or trough, 6 ins. or 8 ins. deep is formed, in which is inserted a number of perforated sharp-edged bars of metal, on which the anvil is allowed to rest on its face or upper surface, either flat or slanting. A sluice communicating with a reservoir of water is then opened, and a force of cold water is allowed to flow upon the face by an upward cast and to pass under the anvil and over the bars to any depth required. By these means a much harder and more regular surface is obtained than by the present mode of manufacture. After this the surface is ground in the ordinary way.—*Mechanics' Magazine.*

Bessemer Steel-making in France.—The total production of Bessemer steel rails in France in the first six months of this year amounted to 19,755 tons, against 10,562 tons in the corresponding period of 1868. It is probable that the French production of this description of rails will show a still further advance in the second half of 1869, as large orders have been given out during the last two or three months by the great French railway companies. Among the more recent orders of steel rails we may mention one for 2,000 tons given by the Orleans Railway Company to the Creusot Works, at £11 7s. 2d. per ton, and another for 3,000 tons, given by the Western of France Railway Company to the Terre-noire Works, at £11 10s. 3d. per ton.—*Engineering.*

RAILWAY NOTES.

Mount Cenis Railway.—The Mount Cenis Railway is a work quite independent of the lines which the tunnel is intended to connect. It cannot possibly be called a rival scheme, but this railway contrasts most remarkably with the tunnel, and affords a complete solution of the difficulty of surmounting mountain ranges at a moderate cost; the practical results of the working of this line, which after all is merely an experimental and provisional one, must be considered by all who view it without prejudice, highly satisfactory.

Only three interruptions have occurred since it was opened, and none of them were from any

cause arising from the system itself. The first in August, 1868, was caused by tremendous floods, which ravaged the whole face of the country, and greatly damaged the chaussée on which the railway is laid. On this occasion the passage across the mountain was stopped for three days only, but was equally blocked for diligences and road wagons, and there was a further partial stoppage during ten days subsequently, when passengers and goods were transported in sledges for distances varying from two to ten miles. The second was in 1869, arising from snow storms and hurricane drifts. The third, in December last, was from similar causes, when the transit over Mont Cenis was never totally closed, but had for some days to be made partially by sledges, and, of course, considerable irregularity unavoidably resulted.

The concession for the Mount Cenis Railway limited the time of its duration to the period of the opening of the Mount Cenis Tunnel and approaches, previously described. I presume most of my audience are aware that the rails are laid on the outer edge of the highway across that part of the Alps, on a narrow gauge, having extremely sharp curves and excessively steep gradients—the curves and gradients, in fact, of a mountain road—inasmuch as the rails follow its surface. The locomotive engines obtain the necessary adhesion, and at the same time insure perfect safety to the train by the lateral pressure of horizontal wheels upon a central rail.

Owing to the limited date for its existence, which will probably be only two years longer from this time, it has been quite out of the question to construct all the necessary protective works which would have been executed for a more permanent line; then it passes over one of the Alpine summits, in a region exposed to the most violent winds (Tormentos) and drifting snow. From peculiar causes, at first perhaps unavoidable, the mechanism of the moving power was, until very lately, imperfect in design and inferior in workmanship, the result being continual repairs, with scant power, and consequently only half loads; the fact being that the old stock could hardly drag 20 tons behind it, whereas the new engines will take up 50 tons, exclusive of their own weight.

The Mount Cenis Railway between S. Michel and Susa is 50 miles in length, and has cost, exclusive of royalty and interest, during construction, about £7,070 per mile; engines and rolling stock, £862 per mile. Total, £7,932, say £8,000 per mile. Had the line been constructed on the usual gauge, and with a more solid permanent way, the cost would have been £3,000 additional, altogether £11,000 per mile. As a maximum expense, obtaining all the unfettered advantages of the system, £12,000, including stations, may be safely reckoned upon as the cost per mile of similar lines in future through a mountainous country. With gradients and curves, such as would be warranted and adopted by lines hereafter laid down on this central rail system, a comparison of distances over such a country along lines prepared for ordinary locomotive engines, to travel over gradients of 1 in 30, the steepest allowable without lateral adhesion, the time of moving, and first cost would probably be as 1 to 3; this difference of distance must also be taken into account when calculating and comparing the cost per mile of working over each system.

As regards the expense of working, the present actual cost on the Mont-Cenis Railway can hardly be taken as a fair criterion. Owing to the exceptional circumstances of its construction, the narrowness of gauge and inferiority of the first engines, the working expenses have been peculiarly heavy—namely, about 5s. per train mile, viz., fuel, 1s. 6d; engine repairs, 1s. 8d.; wages, 6d.—Locomotive power, 3s. 8d.; general charges, 4d.; maintenance of permanent way, 1s. Total, 5s. per train mile. The general charges, repairs, and maintenance thus calculated per train mile would, of course, be reduced by a higher mileage, as the engine repairs are very onerous, but the new locomotives will reduce the expense of moving power fully one-third. The yearly train mileage is about 113,000, or 310 miles daily. On the ascent, the engines are perfectly steady, and equally so on the descent; in either direction, it seems next to impossible for engines or trains to get off the rails; and, in conclusion, it may be stated that up to the end of 1869 about 68,000 passengers have travelled over this line without loss of life or limb.—*Engineering.*

WIRE TRAMWAYS.—This system is by Mr. Chas. Hodgson, and may be briefly described as a continuous development of the plan often adopted in India, Australia, and America, of bridging over rivers by means of a single wire rope, on which loads are transmitted in a bucket suspended by a pulley.

The endless wire rope, now adopted, is supported on a series of pulleys, carried by substantial posts, about 70 yards apart on the average, passing round a clip-drum at the end, and worked by an ordinary movable steam-engine. Boxes, carrying from 1 to 5 cwt., are hung on the rope, in such a manner as to maintain the load in equilibrium and pass over the supporting pulleys with ease. The line is worked at a speed of about 5 or 6 miles an hour, and, the rope being endless, the full boxes travel on one side of the supports; the empties return on the other.

However rugged the country, the line can be constructed quickly, and without necessitating much more engineering work than an ordinary line of telegraph. The cost of a line calculated to transport 100 tons a day, appears to be about £400 per mile, complete for working, and the average cost of transport is about twopence per ton per mile, including maintenance. The plan has been in operation about ten months. About 35 miles of line have been made, and upwards of 100 miles are in construction.—*Engineering.*

CENTRAL PACIFIC RAILWAY.—The Central Pacific Railway Company now operate 948 miles. With the completion of the road, and its inauguration as a portion of the through line, plans for permanent improvements, relative to the perfection of the road and its equipment, were made. These consist, mainly of shops for locomotive and car building and repair at Sacramento; and their progress thus far has involved an outlay of about $1,750,000, in addition to which a million more will be requisite. These works are located at Sacramento, on a tract (filled in from 10 to 20 feet) reclaimed from the low ground of Sutter Lake and the American River. The company here own 65 acres, 23 of which have been filled, and are occupied with the shops, old and new. The shops consist of an engine house (semi-circle) accommodating 29 locomotives; a car shop, 90x230 feet, two stories high; machine shop, 100x205 feet,

eleven locomotives under repair; a blacksmith shop, 60x150 feet, having 21 forges and one blast furnace; a freight-car repair shop; together with boiler, coppersmith, tin and paint shops, oil-house, etc. The power for all these is supplied by a 150-horse power engine. The employees therein number about 900, the pay-roll of whom aggregates more than $10,000 per month. The total force employed by the company numbers about 5,000, in addition to which 2,200 are engaged in the construction of new roads.

The number of locomotives in use are 167, which are all being changed to coal-burning engines,—coal being found at Carrol Hollow, near Ellis Station, on the Western Pacific Road.

The car equipment numbers 2,086,—72 first-class passenger; 635 box; 1,293 platform; 41 emigrant; 9 mail; 16 baggage, and 20 sleeping. The freight cars were all built by the company. The equipment includes several snow plows, 11 feet high, and 10 wide. The cost of the various classes is as follows: Locomotives, $12,500; passenger cars, $7,500; box, $900; platform, $300; smoking, $6,000; sleeping, $11,500. Transportation from the East to Ogden costs—for engines, 50 cents per mile; passenger cars, $500. Cars are not only built, but repaired at Sacramento—it being more economical to haul cars even from Ogden, than to repair them at division stations.

The following table presents valuable statistics of operation on the Central and Western Pacific Roads.

Central Pacific.

Miles run	212,106
Pints of oil	18,349
Cords of wood	6,152
Cost of repairs per mile	8.87 cts.
Cost of engine men per mile	6.89 cts.
Cost of stores per mile	1.59 cts.
Cost of wood per mile	20.09 cts.
Miles run to pint of oil	11.56
Miles run to cord of wood	34.47
Total cost per mile	37.44 cts.

Western Pacific.

Miles run	74,535
Pints of oil	6,888
Cords of wood	2,051
Cost of repairs per mile	12.51 cts.
Cost of engine men per mile	7.16 cts.
Cost of stores per mile	1.88 cts.
Cost of wood per mile	16.51 cts.
Miles run to pint of oil	10.82
Miles run to cord of wood	36.34
Total cost per mile	38.06 cts.

For purposes of supervision to secure safety of trains, the line is divided into six-mile sections, and every mile is daily partrolled,—the section-men, provided with signals and simple tools, thoroughly examining curves, bridges, culverts, switches, and rails.—*Chicago Railway Review.*

Railway Construction in this Country.—The official figures showing the number of miles of railway constructed in the United States in 1869 have not yet been published, but the actual increase is believed to be 7,745 miles, which is far greater than the aggregate of any former year.

The largest amount in any previous year was in 1856, when 3,643 miles of road were built, while in 1868 only 2,978 miles of new rails were laid. Since 1826, when Massachusetts began to lay iron tracks, the construction of railroads in this country has averaged more than 1,000 miles a year, and in the last five years the average has been more than 3,000 miles a year.

Counting the cost of construction at $40,000 a mile, we expended during the last year $300,000,000 in building railways, with probably $300,000,000 for expenditures beyond building. The present distribution of railway lines is nearly as follows: 4,000 miles in New England; 17,000 miles in the Western States; 900 in the Pacific States; 10,000 in the Middle States; 11,000 in the Southern States. The war scarcely checked railway building in the North and West; but it ruined the Southern roads, most of which have since been relaid and supplied with rolling stock, or are now in process of relaying and supply.

And new roads are now building, or are projected, in every part of the country. Texas is pushing through a central road, which may become the southern route to the Pacific Coast. Illinois is building a dozen different roads, which will cover 500 miles. Michigan is engaged upon three new roads, covering 100 miles. Six new roads, extending over 300 miles, are in progress in Iowa. Missouri is pushing on her South Pacific. Oregon, California, Kansas and Nevada are all building new railways. And last, but not least, Virginia projects a great central road through the State, which will make, with connections, direct transit from Norfolk on the coast to San Francisco. These are the leading railway enterprises, and to these should be added the efforts New York and Baltimore are making to perfect their railroad connections with the West.—*N. Y. Evening Post.*

Intercommunication in Canada.—Notice is given in the offical "Gazette" of Canada that an application will be made to Parliament next Session for an Act of Incorporation for a company to build a railway from Ottawa to Fort Garry, Red River, and thence to the confines of British Columbia; also for the construction of a branch from Fort Garry to the most convenient point in the United States, with power also to build steamers and other vessels to navigate the River Saskatchewan and its branches, and the rivers and lakes traversed by the railway; also that the money credit of the Dominion be extended in aid of such company by granting mortgages on the wild lands of the Crown along the route in proportion as the work proceeds. The name of the company will be "The Canadian Pacific Railway and Navigation Company."—*Engineering.*

Penobscot Bay Railroad.—Capt. Buckland, C. E., has completed the surveys and estimates for the Penobscot Bay and River Railroad from Rockland to Winterport, Maine, a distance of 59 miles.—Total cost of road ready for the rolling stock estimated $1,332,819; average cost per mile ready for rolling stock, including stations, buildings, engine-houses, etc., $26,656.38.

A Railway in Japan.—The project for a railway to Yeddo (Japan) is said to have been revived, and the Japanese Government are in a treaty with a Belgian firm for the supply of the necessary plans.

Russian Railways.—It is announced that the Russian Government has just decreed a considerable extension of the railway system in the

Caucasus and elsewhere, in order to open up the country and promote trade.—*Engineering.*

Running Street Cars with Tanks of Compressed Air.—A company organized in New Orleans to utilize several inventions which Mr. Whaley has devised for the application of condensed air as a motive power for cars on city railroads, is soon about to bring the design to a test.

In company with parties interested in the improvement, we visited the foundry of Captain F. Roberts, at the corner of Julia street and the levee, where the apparatus is being constructed. Captain Roberts explained the plan of the apparatus.

The idea is that each car shall have 2 cylinders, or tanks, to contain the compressed air, which is to be used as a motor. These cylinders are to be on the top of the cars, and are to be charged at the depot by an engine worked with steam. Metallic cylinders were first tried, but they were found to be too heavy, and the difficulty of the company has been to find a lighter material available for the purpose. Paper cylinders have been determined on, and Captain Roberts is engaged in making four to be used on the cars, two on each. They are made of strong sheets of paper, laminated to a thickness sufficient to bear the great pressure required to contain the air condensed into steam. The several lamina are adhered with glue, and the paper fabric is strengthened with an envelope of cordage. In connection with these cylinders there is to be an engine, for which a special patent has been taken out, and which is otherwise valuable in its applicability to steam machinery, to receive the condensed air and rotate the wheels of the car.

One of the cylinders was finished. It has been subjected to a trial of 300 lbs. to the sq. in. and had not yielded. Three hundred lbs. to the sq. in., he observed, would suffice as a motor. He had, with a platform car, experimented on a street railroad with far less power than that, and the experiment resulted satisfactorily. He used two old iron cylinders, weighing 1,600 lbs., which leaked through the riveting, and there were 28 persons on the car.

Starting with but 90 lbs. of pressure to the sq. in., and with the weight of cylinders and men mentioned, he made 3¼ miles in 7 minutes and 15 seconds. And as to curves, when the motor was reduced to 15 lbs., to use Captain Roberts' own words, he went around a street corner, "as smoothly as a ball would roll on a billiard table."—*New Orleans Republican.*

French Report on the Employment of Mineral Oils for the Heating of Locomotives.—MM. Sainte-Claire Deville and C. Dieudonné, on the result of experiments made at the instance of the Eastern Railway Company of France, have drawn up the following report on the above important subject:—"Under present circumstances we are of opinion that in consequence of the enormous production of steam in locomotive boilers well-constructed and heated by means of mineral oils, until, by well-conducted and very deep soundings, petroleum, which there is every reason to believe exists in certain well-known spots in France, shall have been brought to the surface, and until all the products of the distillation of coal and schist can be condensed, coal oils may be employed with advantage for the heating of the boilers of locomotives employed to draw heavy trains at high speeds. The following are the results produced by a rather powerful engine, and attached to the report:—The locomotive was of the mixed kind, four wheels coupled, diameter of cylinders 0.42m. (18 ins.), total heating surface 100 square metres, adherent weight 19½ tons. It has to the present time run over nearly 900 miles of line, and the consumption of oil has been at the rate of 5 kilogrammes per kilometre (19 lbs. per mile) when running; to which has to be added 216 lbs. for getting up steam and 60 lbs. per hour when standing with fire alight. The weight of water vaporized was in the proportion of 10.90 kilos. per one kilo. of oil; good briquettes convert only 7.90 kilos. per kilogramme of fuel. The proportion of the two, then, is 138 to 100. The furnace remains in good condition and promises long service, and it may be stated that if heavy oils can be obtained at fair prices, the engine will do good practical work."

A scheme for a Canadian Pacific Railway appears in the newspapers of the Dominion. The length of the line is 2,500 miles, and the capital £20,000,000.

ORDNANCE AND NAVAL NOTES.

The Austrian Torpedo.—The most recent addition to the history of the Torpedo question and its practical development, is furnished by some experiments which have lately been carried out in Austria with a submarine self-propelling torpedo. Our pages bear ample testimony to the ingenuity which has been for several years past expended upon instruments of the torpedo class for defence against the attack of war vessels. During the Russian war, Cronstadt was defended by this class of weapon, sunk in the channels of approach and ready to be fired by electricity. Later on, during the American war, similar means were resorted to for coast and harbor defence. In the present instance we have a powerful agent of destruction, which may be seen at the little port of Fiume, in the Adriatic. We are not able to place a detailed description of this machine before our readers, inasmuch as the important parts are kept secret by the inventor, who prefers to do this rather than to patent his principle, and thereby expose its peculiarity. We can, however, furnish a general idea of its external form and what it is capable of doing, having been favored with these particulars by a correspondent—Mr. Andrew Leighton, of Liverpool—who has recently returned from Fiume, where he witnessed the experiments with the torpedo. In appearance this formidable weapon is like a fish, approximating to the form of the sword-fish. But, besides a projecting snout, it possesses a vertical and two lateral projections, all of which are triggers, and any one of which impinging upon an object with sufficient force explodes the machine. It has, therefore, when in operation, four chances of effecting its purpose—by the direct stroke in front, or the oblique from either side, or the hit above in passing under the bottom of any object against which it may be launched. It can be charged with any explosive material—gunpowder, gun-cotton, dynamite, or nitro-glycerine—and the explosion can be of such force as to drive a hole into the strongest iron-clad sufficient to sink her at once.

The most prominent and important feature in

the invention is the means by which it can be propelled at any required depth below the surface of the water. When the depth at which it is to proceed is fixed upon, it can be driven in a horizontal plane at that depth, towards any mark, at a maximum speed of ten knots an hour. While Mr. Leighton was at Fiume, a commission from the United States, consisting of Admiral Radford and two officers of the United States frigate "Franklin," was engaged in investigating its nature and powers. The experiments had just closed when Mr. Leighton reached the scene, but the inventor subsequently showed the torpedo in operation. It was set off from the side of a boat, and after attaining a depth of some six or eight feet from the surface, it kept, as nearly as could be judged, the same level, and made three circuits, of from 100 to 150 yards each, round the boat, coming to the surface when its propelling power—compressed air—was exhausted. The water at Fiume is very deep and remarkably clear, so that the monster fish was perfectly defined at the depth stated. Its course could also be seen by the bubbles of air coming to the surface in its wake at a considerable distance behind it. The invention of this torpedo is due to Mr. Robert Whitehead, an English engineer resident at Fiume, and chief of an engineering establishment there. The idea was first started by Captain Luppis, a retired officer of the Austrian navy, who suggested to Mr. Whitehead the desirability of a floating and running torpedo, the forepart to be filled with explosive material and the after-part with the motive power, which latter was to be steam. But, on giving his attention to it, Mr. Whitehead soon saw that Captain Luppis's notions were wholly impracticable; that a surface-floating body would never answer the purpose; and that fire or steam in close proximity to explosive material would be so dangerous that this idea of the gallant captain had to be abandoned as worse than useless. He, therefore, set to work upon an idea altogether his own, which was to form a fish instead of a steamboat; and, after innumerable mistakes, failures, and disappointments, his perseverance was at length rewarded by the triumphant success already indicated. Thus to English, and not to Austrian, mechanical genius—as has been incorrectly stated in some quarters—belong the honors of this latest achievement in the art of defensive warfare, which, if it does not render other coast defences needless, must at least be acknowledged as a potent auxiliary for maintaining our island home invulnerable; that is, if our Government have had the wisdom to possess themselves of its secret. It is impossible for any one who has seen this torpedo in operation to hesitate in his judgment as to its superiority over anything of the kind hitherto invented; and it is difficult to estimate the extent to which this single invention will modify the arts of attack and defence by sea.—*The Mechanics' Magazine.*

THE GRAHAM STUART BREECH-LOADER.—At the meeting of the United Service Institution, held on Monday the 17th inst., Captain Selwyn, R. N., in the chair, a paper was read by Captain Graham Stuart, 4th York Volunteer Artillery, on his "Patented System of Breech-loading Cannon." Captain Stuart reviewed the existing systems of breech-loading cannon. The three essentials may be stated as gas-tightness, strength, and simplicity of construction.

Sir W. Armstrong's system supplied the two first, but its complicated construction made it unsuitable for heavy artillery. Mr. Krupp's gun is elaborate, and essentialy weak. The Parsons gun, an application of the system by which a sphere, made to rotate a quarter of a circle, is placed in the breech and perforated according to the bore, gives strength and simplicity, but it has hitherto been impossible to prevent escape of gas. Four years ago Captain Stuart turned his attention to the subject and produced an arrangement approved of by the highest authorities. He has since added improvements, and now brings forward his system as combining these three essential requisites.

An ordinary gun forging, somewhat enlarged in the internal diameter of the breech, is bored as usual, but the part of the boring in the breech is made two or three times as large as the remainder. Into this a sphere of metal, perforated as the bore, is introduced. One face of this has a *spiral* perpendicular projection. This fits against a bronze expansion ring fitted into the rear end of the bore, and acts as a wedge, completely sealing the breech. This sphere is mounted on gudgeons, which pass through the sides of the breech, and is turned by handles outside the gun. It rotates on its axis a quarter of a circle to open or close the breech. The perforation being accordingly in a line with, or at right angles to, the bore, the sphere rests against a heavy perforated breech plug screwed into the solid breech. Through this the charge is introduced; the operation of opening and closing is easy and expeditious; so much so that whereas an Armstrong gun requires ten men to work it, this gun can be worked with eight. The openings in the breech being the smallest possible consistent with breech-loading, strength is secured. The simplicity is evident from the fact that there are only three principal parts of the breech concerned in resisting explosion and force—viz., the plug, ball, and expansion ring. The prevention of gas escape is completely obtained. In the course of repeated trials this has been carefully tested, but none has been observed. Other advantages are the absence of openings into the sides and top of the breech, and the rapidity of fire attainable. The inventor has fired 6 rounds in 35 seconds, equal to 10 rounds per minute. The gun will stand hard work and rough usage. It was left without cleaning for several days, and at the end of the time the breech was opened without difficulty.

A gun made on this principle which has been fired more than 100 times, is deposited in the museum of the institution, and the courtesy of the governing body allows any of Captain Stuart's friends to inspect it. The Ordnance Committee recommended this gun, and Captain Stuart was desired to prepare working drawings for a 300-pounder, to be constructed at Woolwich. He sent in the drawings accordingly, but the War Office finally declined to incur the expense.

In answer to questions, Captain Stuart stated that the principle of the spiral projection prevented any jamming or fracture arising from unequal expansion of the sphere and the side of the breech. He had adopted a groove or "gutter" on the roof of the breech chamber in his working drawing as an improvement on the construction of the gun in the museum, the screw plug of which ten threads bite had never given way, though the gun had been fired with overcharges.—*Engineering.*

The Moncrieff Gun Carriage.—The first of the wrought iron carriages and platforms for 12-ton rifle muzzle-loading guns, manufactured in the Royal Carriage Department, Royal Arsenal, Woolwich, under the superintendence of Col. H. Clerk, Royal Artillery, from designs furnished by Capt. Moncrieff, of the Edinburgh Militia Artillery, was submitted, last Monday afternoon, to a private trial at the proof butts in the Government marshes at Plumstead, for the purpose of ascertaining the amount of counterweight required. Three rounds were fired, without any alteration being required, with projectiles of 250 lbs. weight, and increasing charges of 30 lbs., 35 lbs., and 40 lbs. of powder, the carriage working with the most perfect ease and regularity. At the last round fired a fracture was observed in the axle, near the right cheek of the carriage. The trial, as far as the general principles of the carriage are concerned, was highly satisfactory. The total weight of the platform, elevator, carriage and gun amounted to nearly 50 tons.

Russian Naval Armaments.—The "Cronstad Messenger" says that all the ironclads in the Russian fleet are now provided with new 8 in. and 9 in. steel guns. Some monitors have been armed with 15 in. smooth bores, and all vessels intended for long journeys have 6 in. rifled steel guns. A huge smooth bore gun of 20 in. calibre has been constructed at Perm. All these guns were made in Russia. Every man in the navy, too, is now armed with the new rifle, according to the Baranoff system.

The Martini-Henry Rifles.—Several of the Martini-Henry rifles were forwarded, some time since, to the southwest military district, and are now being subjected to a series of practical tests over the army rifle ranges on Browndown, near Gosport. So far, the opinion appears to be that the new weapon is very superior to the Snider, but that many of the details connected both with the weapon itself and its equipment are open to considerable improvement. The ammunition pouch, carried in front, is decidedly faulty in its arrangement.—*Engineering.*

The 600-pounder Gun at Shoeburyness.—The 12-inch 600-pounder rifled muzzle-loading gun of 25 tons, at Shoeburyness, now being tested as to its power of endurance, is about to be subjected to the ordeal of the second hundred rounds of the 500 hundred rounds ordered to be fired with 67 lb. charges of rifle large-grain powder and Palliser shot and shell of 600 lbs. weight. The mean range of this powerful gun, at 10 degrees of elevation, is found to be about 4,000 yards.

Manufacture of Gunpowder.—It is stated by many writers that no gunpowder was manutured in England until the reign of Elizabeth. But Sharon Turner has shown, from an order of Richard III., in the Harleian manuscripts, that it was made in England in 1483; and Mr. Eccleston, in his "English Antiquities," states that the English both made and exported it as early as 1411. At all events, it long remained a costly article; and even in the reign of Charles I., many complaints were made of its dearness, "whereby the train bands are much discouraged in their exercising."

ENGINEERING STRUCTURES.

Extraordinary Scene on the Humber.—Last week we recorded the failure of the first attempt to raise the sunken pontoon at New Holland. After the system then adopted failed, Captain Hollingsworth, one of the masters of the company's steamers, was allowed to try a system of his own, and he set to work on the following morning. Ten ballast lighters from Hull were obtained, each of a carrying capacity of about 60 tons, and 9 of the company's goods lighters, with a capacity of about 70 tons. All these lighters were strengthened and fortified with massive woodwork, and across each were placed two very strong beams—one across the bow and one across the stern; but none of the beams projected over the sides of the lighters. Thus each of the 19 lighters had attached to it 4 chains, which had previously been fastened to the beams of the pontoon. The whole of the lighters were got over the pontoon between 11 and 12 o'clock on Saturday, and there was only about 1½ hours in which to fasten all down before the flood tide set in. The work was, however, accomplished. About 4 o'clock the strain began to be felt by the lighters, and anxiously were they watched by Mr. Sacre, the company's engineer, Captain Hollingsworth, and Mr. Barber, the superintendent of the locomotive department. By half-past four most of the lighters were pretty well down in the water, and in a few minutes more it was seen that the whole mass moved upward with the rising tide. Half-an-hour more passed away, and still the lighters continued to float, and there was not the slightest sign of any thing giving way. Meantime the tide increased in strength, and it began to bubble and foam amongst the lighters in a manner which showed what a fearful strain was put upon the vessels. Exactly at 5 o'clock the action of the tide forced the pontoon out from the dolphins which for the last twenty years have kept it in position. The eastern end was the first to move, and as the vessels were seen to swing out into the open river the large number of spectators gave three hearty cheers. Soon the whole were floating well out; but the tide, which was flowing with unusual force, caught the east end of the pontoon, and swung it athwart the stream with such violence that the lighter at that end was almost submerged. The two men stationed on board were afraid that the vessel was about to sink, and they at once cut the lashings which held the chains together. The effect was to throw a sudden strain on the next lighter, which was also liberated, and the next, and the next. Cutting adrift then became general, and such a scene ensued as is rarely witnessed. The men on board the lighters appeared to become nervous. The man at the head would cut his chain adrift before the man at the stern could do so, and the result was, that the end or the vessel first liberated flew high in the air, the lighters for an instant standing almost perpendicular. On board one lighter the chains appeared to have been liberated exactly at the same moment, and many of the spectators declared that the vessel jumped clean out of the water. The men with their hatchets made fire fly in all directions, and altogether the scene for about three minutes was one that will not easily be forgotten by those who witnessed it. Before the last lighter had been cut adrift, the pontoon was once more at the bottom; but it is now out of the way of the passenger traffic, which

has been most seriously interfered with since the accident.—*Railway News.*

VANDENVINNE'S STEAM EXCAVATOR.—Upon a plot of waste ground on the north side of Victoria street, Westminster, and about half-way down, may be seen at work at the present moment a steam excavator of novel construction. There it is, pegging into a mound of rubbish, composed of earth, brickbats, and fragments of slate and paving-stones, the whole well consolidated by time and —when we visited the spot—case hardened some 2 in. deep by the frost. The apparatus is the invention of M. Vandenvinne, of Belgium, who has had a machine at work in that country with satisfactory results. The present excavator is to be considered only as a model, although one which practically illustrates the principle of the invention. It is self-contained, and consists of a boiler and steam-engine, which gives motion to the excavating apparatus. This consists of a pair of vertical shafts, placed in front of the machine, and around which are keyed a series of horizontal picks, placed radially so as to command a circle. Both the shafts have an inward motion, and the picks are so arranged as to pass between each other's spaces. As the picks bring the soil down, it is carried by them into a set of buckets on an endless band, set at an angle, and running over pulleys in the rear of the picks. The buckets deliver the soil on to an endless horizontal platform placed over the back of the machine, and this in its turn conveys the soil down a shoot, depositing it in the rear of the apparatus. The shoots, however, can be arranged so as to form a spoil bank on each side of the machine, if necessary, instead of making one in its wake.

The forward motion is effected by means of another endless platform carried over a set of rollers in the lower part of the machine. When out of work this platform can be raised, and the machine is then carried on a set of wheels by which its transit from one point to another is effected. The excavator can be set to work either at an upward or a downward angle of inclination, as well as at a dead level. Although this is only to be considered as a model machine, it is not so small as might be imagined; it measures 12 ft. in length, excavates a width of 5 ft., to a depth of 3 ft., and weighs about 4 tons.

The Belgian machine to which we have referred was of larger dimensions, being 25 ft. long, cutting to a width of 10 ft., and weighing about 15 tons. Upon our recent visit to Victoria street, we found the machine at work on the mound of rubbish we have mentioned, regularly advancing at a rate of travel of about 3 in. per minute. There were occasional interruptions, owing to the presence of large blocks of paving stone, which naturally jammed the picks; but with these exceptions the machine worked steadily on, brickbats and slates being readily disposed of by the picks and buckets. This steam excavator is being introduced into England by Mr. C. F. T. Young, of the Adelphi, who is preparing working drawings of the machine, which, with a detailed description, we shall shortly place before our readers.—*Engineering.*

THE NEW TUNNEL IN CHICAGO.—A second tunnel is to be built under the Chicago River at Chicago, for the purpose of connecting the two divisions of the city. The work has already begun. The Chicago *Tribune* gives a detailed description of the proposed tunnel, from which we take the following facts and figures:

"The tunnel is to be placed with its centre line in the centre of La Salle street. The southern approach is to begin 40 feet north of the north line of Randolph street, and the north approach to terminate at the south line of Michigan street. The bottom of the tunnel, or top of invert, in the centre of the river is to be 35 feet below low water. The grades between the ends of the approaches and the centre of the river to be uniform, except on the river portion of the work, where it will be less than on the approaches. The tunnel under the river is to consist of three passageways. The east one for foot passengers, and the other two for horses and vehicles drawn by horses. The east passageway is to be 12 feet high between the bottom of the upper arch and the top of the invert. The width of this passageway is to be 10 feet. The other passageways are to be 11 feet wide, their inverts to be segments, the upper arches to be from three centres; a flagging course of 10 inches thick is to be laid entirely across from one side to the other of the tunnel. The section of the tunnel above described is to extend entirely across the river, a distance of 300 feet. The flagging course over the top of the tunnel will extend for a distance of 280 feet only, including two and a half feet to be built under each dock wall. Beginning at a point 150 feet each way from the centre line of the river, the section of the tunnel changes to a single opening or passageway, beginning here with a width of 24 feet 4 inches, and diminishing to a width of 19 feet 6 inches, in a distance of 40 feet, or to points 190 feet on each side from the centre line of the river. At the point 150 feet each way from the centre line of the river, the centre of the single passageway begins with a height between the top of the invert and the bottom of the top arch of 21 feet.

"The opening approaches to the tunnel on each side, and the passageway for horses, are to be paved with wooden block pavement (the whole distance being 1,890 lineal feet), resting on lake shore sand, in the manner shown on plans, and according to the usual specifications of the Board of Public Works for such pavements.

"The contract requires that the river shall be entirely free and unobstructed, as also North and South Water streets, by the 1st day of April, 1871, and the tunnel to be completed and ready for public use by the 1st day of July, 1871. This is about the same length of time employed in the construction of the Washington street tunnel. The total cost of the La Salle street tunnel is expected to be upwards of $475,000."

THE FOOT BRIDGE AT PRAGUE.—Our readers will doubtless remember that in June, last year, a new bridge was completed and opened at Prague. This bridge—the Franz Joseph—was designed and constructed by Mr. R. M. Ordish, of Westminster, upon his rigid suspension principle, which has been described in our columns. The success of this principle led to the construction of another bridge upon the same system and across the same river—the Moldau. This second bridge is for foot passengers only, and has the peculiarity of having one central tower and two abutment piers, thus forming two half spans. This special feature was necessary, in consequence of the character of the river bed and other local considerations. This bridge has a platform width of 11 ft., and each span is 305 ft. 6 in. in the clear. The works of the

bridge having been completed, it was tested on the 22d and 23d of last month by a commission appointed by the municipality, under the superintendence of the resident engineer, Mr. Max am Ende. The test load consisted of 42,500 bricks, equivalent to a load of 457,640lbs., equal to a distributed load of about 64lbs. per square foot. This load remained upon the platform for one hour. During that time observations were made at each span; the maximum deflection was 6¼ in. and 6⅞ in. respectively; the anchorage chains extended over $\frac{1}{16}$th and ⅛th of an inch. The estimated deflection was 7½ in. On the 24th the bridge was cleared of its load, when the permanent set was found to be half an inch, the anchorage chains having returned within $\frac{1}{14}$th of an inch to their original position. The bridge is found to be exceedingly steady under uneven loading, and it has been exposed to heavy gales with like results.—*Mechanics' Magazine.*

Powerful Turbines.—A correspondent of the "American Odd Fellow" thus describes the turbines used in the Mastodon Mill, in the village of Cohoes, New York: "The entire number of looms in this mill is fourteen hundred and eighty-six; five hundred of which are located on the first floor.

"These looms and the other machinery of the mill are driven by three immense turbine water wheels, made by the Ames Manufacturing Company, which operate the main shaft, and possess an aggregate driving capacity of over 1,100-horse-power. This pit having an extreme depth of 40 ft., with a floor 25 ft. from the surface, which hides the water wheels from a top view, is, in reality, an underground two story building. Three mammoth cast iron cylinders, 8 ft. each in diameter, convey the water from the canal on the west side of the building to the wheels; the volume of water being regulated by a sort of tiller located in the pit, and connected with flood-gates. The perpendicular shaft of each turbine is connected with the main shaft by bevelled gear, and the united power exerted, if so applied, would reverse the motion of the great Burden water wheel at Troy, and drive the machinery of a good-sized manufactory besides. The shaft to which this wondrous power is applied is supported by three granite abutments, and forms the axis of six ponderous driving pulleys, 12 ft. each in diameter. The immense belts which radiate to all parts of the building are in keeping with the massive pulleys and gearing. These are each two feet wide, and the longest one reaching to the fifth story, measures nearly 200 ft. At the north end of the pit, two rotary force pumps are located, which, in case of fire, can be instantly geared to the main shaft by means of a sliding cog-wheel, and are jointly capable of throwing six thousand gallons of water per hour.

Mont Cenis Tunnel.—The long tunnel popularly known as that of Mont Cenis, really passes below a different mountain. It connects the railways of Italy, converging at the town of Susa, at the foot of the eastern slope of the Alps, with the railways of France, at present terminating at the village of St. Maurice, in Savoy, west of the range. The mode of driving this tunnel has been before described; at present I have simply to note its progress. The total length of actual tunnel is 12,220 metres, say 7⅝ English miles; the aggregate length of the driftways, completed from each end, is 10,598 metres, or 6⅝ miles; so that there is only one mile of driftway to finish; the rate of progress being from 3½ to 4 yards a day, the piercings from end to end may be expected early in the spring of 1871. The enlargement to full size and the lining of the tunnel, is always kept up to about 300 yards behind the headings in each direction. Assuming that the tunnel, with the deep cutting approaches at each end, will be finished in the course of the year 1871, it will have occupied thirteen years in construction, at a cost not less than four millions sterling.—*Engineering.*

A Big Canal Scheme.—The California Commissioners on Swamp and Land Reclamation have reported favorably upon a project for an extensive canal through a portion of the Sacramento valley. This report, with the estimates to follow it, will be made the base of a bill providing for the issue of $4,000,000 of State bonds, to be paid by a tax levied on the reclaimed lands. Such a project, says the "San Francisco Bulletin," is of doubtful constitutionality, even if it were politic, which it is not, to loan the State credit for so large a sum, or for any sum whatever, in behalf of a local and private improvement.

The Induration Process.—Mr. Ransome's method of water-proofing walls by means of successive solutions of silicate of soda and chloride of calcium, which has been applied with so much success to many public and private buildings in England, is being used extensively in India to arrest the decay of many brick structures upon railways in that country. Amongst others we may note the Waree Bunder Works, upon the great Indian Peninsula Railway, which were constructed of such inferior material that a rapid deterioration speedily followed the construction of the works, and the crumbling of the bricks left no alternative apparent save that of rebuilding. It was, however, determined to experiment with Mr. Ransome's process, and, accordingly, in 1868, it was extensively applied to the failing buildings, with the result of effectually stopping the decay, and of placing so fine and hard a surface upon the bricks that the material, which before could be crumbled by the touch, received a surface so hard as to resist the scratching from a steel point. In this manner extensive workshops and a chimney shaft were, at an insignificant outlay, rescued from destruction and rendered sound and durable.—*Engineering.*

NEW BOOKS.

The Metallurgy of Iron and Steel, Theoretical and Practical: in all its Branches, with Special Reference to American Materials and Processes. By H. S. Osborn, LL.D., Professor of Mining and Metallurgy in Lafayette College, Easton, Pennsylvania. Philadelphia: H. C. Baird. 1869.

The metallurgy of iron has lately had very much thought expended upon it, yet the subject is by no means exhausted, and the number of results scientifically determined and systematically arranged is so small that metallurgists, professional or practical, all welcome very eagerly any additions to our stock of knowledge. We hoped when we saw this ponderous volume of nearly one

thousand pages, by Professor Osborn, not only to find much that should be new and valuable, but a work that should correctly represent the state of the American iron industry. The least that could be expected of such a work was that it should be a careful and accurate résumé of the most important facts relating to the subject, and that it should be written in an intelligible style. In perusing the book we were sorry to find all our hopes and expectations speedily and entirely disappointed.

From the preface we learn that Professor Osborn first intended simply to re-edit Mr. Overman's treatise on iron, but finding it impossible, on a "thorough examination," to make it represent correctly the present stand-point of iron metallurgy, he therefore wrote "a work almost entirely different in method and in matter." "There was, nevertheless, so much material in Mr Overman's book which was useful," we read in the preface, "that it has been introduced and acknowledged, either by the use of his name or by enclosing the quoted matter in brackets." The "so much material" referred to comprises over three-fourths of Overman's work, making fully one-half of Osborn's, with Overman's original illustrations, as published in 1850, and we were surprised to find the numerous and well-known inaccuracies and blunders of Overman retained in full.

For instance: In the original work appeared an impossible analysis of peat ashes, which was, perhaps, a misprint. But Dr. Osborn seems to have such implicit confidence in Overman as to deem it unnecessary to question any of his statements, so here (page 184) we have perpetuated an analysis of peat ashes of unheard-of composition, containing no less than 133¾ per cent. of oddly combined ingredients. An error once started is hard to stop, and this absurd statement once more revived is destined, doubtless, to meet us often. It has already found its way into the columns of a prominent technical journal, the "Engineering and Mining Journal," where the article on peat was given in full with editorial approval.

Welter's law, that "the amount of heat liberated by the chemical combination of various substances with oxygen is directly proportional to the amount of oxygen consumed," long since proved to be inaccurate, is retained by Osborn as "one of the most useful inculcations of chemistry" (page 245).

Overman's work contains, it is true, many useful practical details of the manufacture of iron, but is wofully deficient and inaccurate in the scientific treatment of the subject. The fact that any one should endeavor to build up a work on such a foundation does not promise well for the superstructure.

The first chapter in the book, on the general principles of the chemistry of iron, is, doubtless, original with Professor Osborn, at least it has never been our lot to meet with anything so remarkable in chemical or metallurgical literature elsewhere. It is, perhaps, the most incoherent, obscure, incorrect, and puerile chemical production that has been written since the days of the alchemists. With the intention of making himself intelligible to the most ignorant of his readers, he playfully calls carbonic acid the *rust of carbon*, analogous to the rust of iron. He states incidentally that heat will expel oxygen completely from oxide of iron—a statement so manifestly false as to need no refutation. On combustion his ideas are ludicrously vague. It is clear to him that carbonic oxide, being the product of the partial oxidation of carbon, is a combustible gas; not, however, because it is capable of combining with more oxygen, but because "carbon is consumable, and oxygen, as we have said, supports combustion; all the conditions therefore of flame or fire exist in carbonic oxide." Carbonic acid, being the product of the complete oxidation of carbon, will not burn. The Professor, duly recognizing the fact, is puzzled to know the reason why; for, according to his theory, it ought to be more combustible than carbonic oxide. It remains, notwithstanding, obstinate in its combustibility, and he is forced to content himself with calling the fact "an anomaly." We can imagine, when the Professor contemplates the combustibility of hydrogen, how surprised he must be that water does not burn! He should peruse as soon as he can some elementary work on combustion, and meantime rest satisfied with the reflection that what has been already completely burnt cannot be burnt again.

The looseness of style in which the book is written is apparent on every page. For instance, on page 25 we read: "It (phosphoric acid) combines with the iron, to the great vexation of the iron manufacturer." Phosphorous, not phosphoric, acid, is meant.

On page 24: "The oxide of silicon is silica or quartz"—which is inaccurate; what is meant is, that silica is *an* oxide of silicon—"and silica is the substance silicon combined with oxygen, making silica."

The following sentence, on page 158, may be said to be well mixed: "The properly sized crucible having been taken, line the interior with charcoal powdered and mixed with water, or water and molasses, or molasses alone, previously well mixed with the coal and the latter thoroughly triturated into the mass in the mortar." Mr. Dixon, the well-known crucible maker of Jersey City, will, perhaps, be surprised to find himself quoted as saying (p. 540), "that the nearer a crucible comes to being all plumbago, the quicker it will melt."

The particulars of original experiments are fortunately very rare in the book, as Dr. Osborn seems to be incapable of judging correctly of the results he obtains. From three experiments, tried on silicious, argillaceous, and calcareous ores, he concludes that any of these ores, on being strongly heated in a crucible with a well-fitting cover, without the addition of carbon or any reducing agent, will become partially reduced to metallic iron, the amount of the reduction being in proportion to the amount of lime present. We do not give his conclusions in his own words—they are too obscure; but we have, we believe, correctly interpreted his meaning. Dr. Osborn must not expect to overthrow so easily the accumulated evidence of generations, that oxide of iron, whether in the presence of silica, clay, or lime, cannot be decomposed by heat alone.

The directions given for the analyses of ores, fuels, and fluxes, are entirely superfluous. For one acquainted with chemical methods they are crude and inaccurate, and to one not familiar with chemical manipulation they must be utterly inexplicable. The Professor's own ideas of chemical analysis are evidently very vague. He divides the "wet assay," for instance, into, first, volumetric assay; second, chemical analysis. It will, doubtless, be new to many that volumetric is to be distinguished from chemical analysis.

The confusion and misuse of scientific terms is a peculiar feature of the work. On page 316, we are informed that the furnace is divided into four zones of *specific heat*, meaning specific action, for which blunder Percy is made responsible on page 326. On page 185 we read: "The specific gravity of a cord of wood is from two to three thousand pounds." This is retained from Overman. On page 27, manganic acid is called manganese acid. For pure oxide of iron (page 143) we read oxide of *pure malleable iron*. *Determination* of substances is used for *detection* (page 117). On page 169 we hear of a protosalt being *reduced* to a sesquisalt. On pages 132 and 913, *chromic iron ore* is called *chromate of iron*.

Scientific nomenclature has been enriched by the Professor with some original terms, such as, *oxygenated* and *carby-oxygenated crude iron!* (pp. 140, 141). *Quality of heat* is said to mean *temperature* (p. 243).

In the preface, Dr. Osborn acknowledges that in the chapter on the special properties of iron and its compounds he has been greatly indebted to Percy's work. Any one familiar with the able treatment of this subject by Percy will be incensed by the way his statements and experiments have been misquoted. It looks as if Dr. Osborn had turned over the leaves of Percy's book and taken sentences at random, without regard to their connection or relative importance, always altering the language to the detriment of the idea. We give a few quotations by way of illustration: We read in Percy's work ("Metallurgy of Iron and Steel." London. 1864), page 79: "By washing the residue the arsenic is separated as soluble alkaline arseniate, while pure sesquioxide of iron is left." Osborn (page 107): "On washing the residue, pure alkaline arsenic is removed and pure sesquioxide of iron remains." Percy (pp. 98-100) gives the details of six experiments on the reduction in silicate of the protoxide of iron by carbon, from which is proved that "only two equivalents of the protoxide of iron in tribasic silicate can be reduced by carbon." Osborn (page 111) did not see the drift of the experiments and overlooked the result, and has given merely a condensed account of the first experiment with this result: "Product: well-melted buttons of white iron." At the conclusion of an interesting series of experiments by Percy on the carburization of malleable iron by means of hydrogen which has passed over charcoal at a red heat, he says: "The questions suggested by this point are, Did hydrogen under these conditions take up any carbon, or was the gaseous compound of carbon which caused the carburization of the iron simply evolved from the charcoal employed?" "The question arises," according to Osborn, "Was it from the hydrogen mechanically taking up carbon, or was it from hydrogen eliminating, by some chemical affinity, the, so to speak, latent carbon of the charcoal, and thus charged with carbon, passing over to the piece and carburizing it?" Such a jumble of words may convey an idea to Dr. Osborn, but will not edify many of his readers.

In the chapter on iron ores, Dana is also misquoted. We read (p 43): "Dana includes all these varieties" (bog-iron ore, etc.) "under the specific name of Limonite." In Dana's "System of Mineralogy," 1869, page 172, we read under Limonite: "Only *part* of stalactitic limonite, brown or yellow ochre, bog ore, and clay ironstone belong here."

Instances might be multiplied indefinitely of this system of garbling extracts without regard to the author's meaning, but we forbear. We must not forget to mention that the element fluorine, which has up to the present time defied all efforts made to isolate it, has been recognized by Dr. Osborn. "Liberated fluorine" from cryolite, we are informed incidentally, attacked clay crucibles to such a degree that the use of cryolite had to be abandoned at the American Steel Works, Brooklyn!

The book is also sadly deficient in regard to recent improvements in the manufacture of iron. On the important subject of coking, we have, in addition to Overman's work, nothing but the single method used at the Cambria Works, Pa., for coking in heaps. The large number of coking furnaces that have come into use in the last twenty years have been completely ignored. On roasting of ores we have, in the way of novelty, merely the three methods of illustrations, given in Petitgand & Ronna's appendix to the French translation of Percy. The many new forms of roasting-kilns in which waste gases are used are entirely omitted. Westman's kilns, introduced into this country by Mr. Hewitt, might have been at least mentioned, as the book has "special reference to American materials and processes."

Steel is discussed and dismissed in 57 pages. We find here no reference to the Siemens-Martin process, and the Bessemer process as practised in America is not once mentioned.

In fact, one would infer from Osborn's book that the manufacture of iron and steel, since Overman's treatise was published, had been practically at a stand-still. An attempt has been made, it is true, to bring that work up to date, but with so little care, industry, and research, that the new book is hardly better than the old.

We feel that such a work as this cannot be severely enough condemned. Reviving a bad book that should have been allowed to remain in oblivion, and taking it as a groundwork, the author has added but little that is useful and much that is false, the whole being written in a most incoherent, slovenly style.

THE PNEUMATIC SEWAGE SYSTEM TREATED WITH REFERENCE TO PUBLIC HEALTH, AGRICULTURE, AND NATIONAL ECONOMY. By DR. G. ZEHFUSS. Translated by Dr. F. COAR, of Philadelphia. With an introduction to Captain CHAS. T. LIERNUR's "Pneumatic Sewage System." Cologne. 1869. For sale by Van Nostrand.

Besides the subjects enumerated in the title, this pamphlet describes the sewage systems employed in different countries, and estimates their relative sanitary and economical values.

The Pneumatic System here proposed for large towns is certainly very complete in its design.

THE DRY EARTH SYSTEM. By H. J. & J. W. GIRDLESTONE. London: E. & F. N. SPON. 1869. For sale by Van Nostrand.

This is an able elucidation of the merits of the earth closet, already somewhat familiar to people of this country.

A TREATISE ON ROLL-TURNING FOR THE MANUFACTURE OF IRON. By PETER TUNNER, Member of the Austrian Ministry of Mines. Translated and adapted by JOHN B. PEARSE, Metallurgist Engineer and Manager at the Works of the

Pennsylvania Steel Company. New York : D. Van Nostrand Publisher.

The subject of roll-turning has been so scantily treated in all the books which have described the manufacture of iron that very little that is useful can be gleaned from their pages. None of the late books on the subject contain more information than was given by Karsten in 1841, though since that time extraordinary progress has been made in the art.

The chief ground of this neglect of this vital branch of industry is, in my opinion, to be found in the fact that those who have lately written on iron metallurgy have not, as a rule, been practical metallurgists, but only metallurgical chemists, and, therefore, they have neglected as trivial such things as *passes*, or, perhaps, have even held it beneath their dignity to write about them.

The translator has added many practical and valuable suggestions to the work. The text is illustrated by upwards of 40 wood-cuts, and an atlas of ten large folio plates.

Iron Truss Bridges for Railroads. Methods of calculating strains, with a comparison of the most prominent Truss Bridges, and new formulas for bridge computations ; also the economical angles for struts and ties. By Brevet-Col. Wm. E. Merrill, U. S. A. New York : D. Van Nostrand.

It is impossible to overrate the importance of a clear understanding of this subject, especially by railway engineers.

As iron and steel supersede wood in bridge construction, and spans are increased beyond all former precedent, the necessity for economy in use of material, and for a proper distribution of it, is greater than ever.

The custom is by far too common to build a truss bridge without regard to proportionate strains. Some empirical formula by application of which the greatest forces are met, is made to do service for all like parts of the same structure. In this way wooden bridges, like the Burr, Howe, and Town's Lattice, are overloaded with timber at the centre, or else poorly supplied with material at the ends. The rude formulas by which these moderate spans were made safe had been made so by the corrections gradually suggested by previous disasters.

Now that there is a growing ambition to accomplish clear spans of 500 or 600 feet, it is more than ever necessary to investigate the nature and amount of the forces to be met.

Col. Merrill's book affords, by easy mathematical processes, the most satisfactory methods of determining the forces residing in the various parts of our leading varieties of American Truss Bridges. His analyses include the Bollman, Fink, Post, Linnville, Murphy-Whipple, and the Triangular bridges.

The book is of quarto form and well illustrated.

A Hand-Book of Practical Telegraphy. By R. S. Culley, Engineer to the Electric and International Telegraph Company. Published with the sanction of the Chairman and Directors of the Electric and International Telegraph Company, and adopted by the Department of Telegraphs for India. Fourth edition revised and enlarged. New York: D. Van Nostrand. publisher.

This is a thoroughly scientific treatise, but may be read with ease and profit by the most unscientific reader.

The author begins with the rudimentary phenomena of electricity, but embraces within the limits of his treatise some of the most intricate problems of practical telegraphy.

The theory and practice of detecting faults in submarine cables will prove especially interesting to the general scientific reader.

What are the Stars? or a Treatise on Astronomy for the Young. By M. E. Storey Lyle. London : Sampson Low, Son & Marston. 1870. For sale by Van Nostrand.

Within the last two years three or four books have appeared designed to aid the student in astronomy in tracing the constellations.

The volume before us is the most attractive-looking star guide we have ever seen, and, judging from its abundance of illustrations, we should think it quite as serviceable as the best of its predecessors.

It is a 16mo volume, and contains 100 engravings.

Hand-book of Physical Geography. By Keith Johnston, Jr., F. R. G. S. Edinburgh and London : W. & A. K. Johnston. 1870. For sale by Van Nostrand.

A brief outline of the science of physical geography is presented in this little work. It is evidently designed for beginners. The outlines of the whole subject are well presented, and in a neat and comparatively inexpensive volume.

No diagrams or maps are given in the book.

A New System of Ventilation, which has been thoroughly tested under the patronage of many distinguished persons, being adapted to parlors, dining rooms, sleeping rooms, kitchens, basements, cellars, vaults, school and court rooms, prisons, hospitals, restaurants, coal mines, ships, steamboats, etc., etc.

A book for the household.

Third edition, enlarged with new illustrations by Henry A. Gouge. New York: D. Van Nostrand, 1870.

Reports on Observations of the Total Eclipse of the Sun, August 7th, 1869, conducted under the direction of Commodore B. F. Sands, U. S. N., Superindendent of the United States Naval Observatory, Washington, D. C. Washington Government Printing Office, 1869. For sale by D. Van Nostrand.

The details of the work, under Government direction, upon the great eclipse, are set forth in a handsome quarto of two hundred pages, and illustrated with twelve photo-lithographs and several wood-cuts.

The completeness of the equipments of the observing parts, and the favorable conditions of position and weather under which the work was accomplished, make the present report a desirable addition to scientific libraries.

Notice of Roebling's Bridges. From "Engineering," Jan., 1870.—Not only are the various portions of the structures described, the strains upon every part under varying conditions elaborated, but the weights and costs are figured out to the minutest degree.

In this careful manner several examples of large span bridges are dealt with, and the volume concludes with a page or two of descriptions, and

some designs of short span bridges, in which wire cables are introduced as auxiliary means of support in connection with the trusses.

The whole of the work, brief though it is, bears upon every page the trace of a master in his profession, and of one especially, who, arriving at results in the simplest and most straightforward way, had the power, also, of conveying his ideas clearly.

The book itself is well produced, the engravings beautifully executed, and possessing all the merit of complete working drawings.

A Treatise on Ore Deposits. By Bernhard Von Cotta, Professor of Geology in the Royal School of Mines, Freiberg, Germany, translated from the second German edition by Frederick Prime, Jr., Mining Engineer, revised by the author, with numerous illustrations. New York: D. Van Nostrand, 1870.

The first hundred pages of this valuable work are devoted to a description of the various forms of metalliferous deposits and a discussion of the theories of their formation.

The latter portion of the book, or "special part," as the author terms it, describes minutely the ore beds of Europe, and their geological surroundings.

It is well painted, abundantly illustrated, and is a valuable addition to the literature of economic geology.

The Chemical Forces—Heat, Light and Electricity. With their application to the expansion, liquefaction and vaporization of solids; the steam-engine, photography, spectrum analysis, the galvanic battery, electro-plating, the electrical illumination of light-houses, the fire-alarm of cities, the atlantic telegraph. An introduction to "Chemical Physics." Designed for the use of academies, colleges, and medical schools. Illustrated with numerous engravings, and containing copious lists of experiments, with directions for preparing them. By Thomas Ruggles Pynchon. Hartford: A. S. Hale & Co. 1870. For sale by Van Nostrand.

The recent progress in physical science has created a demand among instructors for more extended treatises upon the above subjects than they have heretofore been able to obtain. The work of Prof. Pynchon seems well adapted to meet such a demand. It is well arranged and copiously illustrated.

MISCELLANEOUS.

Stump Drawing by Steam.—In the neighborhood of Tattershall, in Lincolnshire, are some hundreds of acres of waste land, of a light sandy and gravelly nature, encumbered by the stumps of Scotch fir trees, cut down some years ago, and only growing wild grass and ling. It has been proved, however, by experiments made in a small way, that this land, if properly cleared, drained, and clayed, is capable of bearing good root crops; but, until lately, the great expenditure of labor incidental to extracting the stumps and roots of the fir trees has prevented the work of reclamation from being carried out to any great extent. A short time ago, however, Mr. John Robert Bankes, the agent and steward to Lord Fortescue, to whom the land belongs, determined to attempt drawing the stumps by means of steam ploughing engines; and eventually, after a consultation on the subject with Mr. Toepffer, of the North Lincolnshire Steam Cultivating Company, a contract was entered into by this company to perform the work.

The stumps are from 12 in. to 20 in. in diameter at the base and stand from about 8t. to 10 ft. apart, and the operation of drawing them, which has now been going on successfully for some weeks past, is performed as follows: Two of Messrs. John Fowler & Co.'s 20 horse steam ploughing engines are placed about 200 yards apart, with a row of the tree stumps between them, and, in commencing, the wire rope from the drum of one engine is led across to the second engine, passed round a snatch block there, and led back and attached to the engine from the drum of which it was uncoiled. The snatch block just mentioned is connected by a strong chain to a two-fluked anchor of a form suitable for taking hold of the stumps, and to a chain at the back of the anchor is attached the rope of the second engine. Things being thus arranged, the anchor, which is, as it were, suspended between the engines, is raised by four men and placed about 2 ft. in the rear of the first stump to be extracted. The engine connected with the snatch block is then made to haul upon its rope, when the anchor is drawn into the ground, takes hold of the stump, and extracts it with the utmost ease. As soon as the root is clearly pulled up, the second engine hauls back the anchor to clear it, and all is then ready for acting on another stump. When fairly at work, the drawing of the stumps is performed at the rate of 1 per minute.

The pull which each engine is capable of exerting on the rope is about 8 tons, so that, by the aid of a single snatch block, a pull of 16 tons can be exerted, or by means of a double snatch block a pull of over 30 tons. The double snatch block, however, is only required for the largest stumps. Besides the two 20-horse engines, two others of less power are engaged in drawing the extracted stumps into heaps, and thus clearing the land for ploughing. The whole operation has, as we have said, been thoroughly successful, and all parties concerned are to be congratulated on opening up a new and useful field for the employment of steam ploughing engines.—*Engineering*.

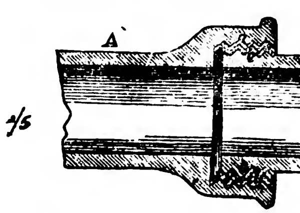
Chinese Engineering Art.—China is by no means a progressive country, either in arts or sciences, but several of the industrial methods pursued by her people are unique and curious, and some of them are worthy of imitation in principle, if not literally. Of these there are two precautions adopted in working the mines of coal, which are tolerably numerous in the Celestial Empire: "1. Whenever gas of a mephitic or inflammable character is encountered in the pits, a bamboo tube is introduced throughout the various workings, terminated at the lower extremity by a conical point. This is inserted in the fiery or dangerous seam, and the gas conducted away to the external atmosphere. 2. A timber framework is erected occasionally to support the roof, but only for so long as it is required to maintain a free passage underneath. When there is no further necessity for it, the general practice is to fill up the excavated spaces by earth well rammed in and consolidated. All 'creeps and falling in the roof are thus avoided.'"

The Chinese have no industrial use for salt; but

of course, they require it for seasoning and preserving articles of food. Some salt is obtained from mines o f rock salt, some from brine wells. "A simple but rather ingenious method is employed for raising the salt liquid from the wells. A long bamboo is hollowed out, and a valve, opening inwards, is fixed to the lower end. This is lowered down and sunk into the liquid, which rises through the valve. As soon as the bamboo is considered to be full it is hauled up, the pressure of the contained fluid keeping the valve close. In one particular province of China the salt pits are not free from an inflammable gas. This is utilized for heating the boilers in which the saline liquid is evaporated, thus proving that the natives have an eye to the economy of fuel. The boilers are erected near the pits, and the gas brought to them in bamboo tubes, furnished with a copper burner. In the northern portions of the empire salt is used for preserving and embalming the bodies of defunct mandarins and officials of high position."

Vessels for containing oils and varnishes which corrode metals, wood, etc., are made by the Chinese as follows: "An open carcass or frame is made of small pieces of bamboo closely entwined. The interior of the carcass is lined with paper, manufactured also from a bamboo of an inferior quality, and is caused to adhere to the frame by a particular description of paste, prepared from a mixture of flour and a hot and strong solution of gelatine. This lining is covered by a layer of mastic composed of lime, sand, and a paste made from peas. When it is dried it is in its turn covered with paper, and the vessel is complete and ready for sale."—*Engineering.*

A NEW PIPE-JOINT.—M. Fragneau has invented a method of joining pipes which he claims to be superior to the ordinary method, in economy, convenience, and efficiency.



The figure represents a longitudinal section of one of these joints. Inside the ends of A and B are cast corresponding screw threads, male and female. The diameters differ by an amount sufficient to admit of the following operation:

A copper mould, with a carefully-turned thread, is inserted in A at the joint, so as to allow of casting upon it a thin ring of lead, *a*, which adapts itself to the thread of the casting. A similar ring, *e*, is cast upon the extremity of B. These rings should be slightly conical, and of such thickness that both will well fill the space *b d*. The parts should be well greased with a mastic of plumbago and tallow. When the parts are screwed home, the joint will be hermetically closed.

The operation is performed quickly, and requires no special precaution or skilled laborers. It is also economical of lead, a fact that makes it superior to the ordinary method.

The lead rings may be cast separate, if desired, and then slipped upon the ends. Again, a single lead ring may be employed. This method of jointing is applicable to tubes of all dimensions and of all angles.—*Condensed from Le Génie Industriel.*

HEAT PARADOX.—Mr. Spence has made public an apparent paradox in the science of heat, whereby he is enabled to raise a higher temperature in certain solutions by steam of 212 degs. Fahr. He selected a solution of a salt (nitrate of soda) having a high boiling-point, about 250 degs. Fahr. The nitrate of soda was placed in a vessel surrounded by a jacket; steam was let into the intervening space until a temperature of nearly 212 degs. Fahr. was obtained; the steam was then shut off and an open pipe immersed in the solution, and steam from the same source was thrown directly into the liquor; in a few seconds the thermometer slowly, but steadily, moved, and, minute after minute, progressed until it touched 250 degs. Fahr. This unexpected fact has become to the author of great practical value. As a corroboration of the theory which seems to explain the apparent paradox, the author finds that the temperatures of his solutions are in the exact ratios of their specific gravities, and have no connection with the temperature of steam, which never exceeds 212 degs. Fahr. The greater the specific gravity of his solutions, the higher the boiling-point; and, therefore, whatever the boiling-point of the solution in water of any salt, to that point, or nearly, will steam of 212 degs. Fahr. raise it.—*Quarterly Journal of Science.*

GLUE WHICH WILL UNITE POLISHED STEEL.—The following is a Turkish receipt for a cement used to fasten diamonds and other precious stones to metallic surfaces, and which is said to be capable of strongly uniting surfaces of polished steel, even when exposed to moisture. It is as follows:—Dissolve five or six bits of gum mastic, each the size of a large pea, in as much spirit of wine as will suffice to render it liquid. In another vessel dissolve in brandy as much isinglass, previously softened in water, as will make a two-ounce phial of strong glue, adding two small bits of gum ammoniac, which must be rubbed until dissolved. Then mix the whole with heat. Keep in a phial closely stopped. When it is to be used set the phial in boiling water.—*The Stationer.*

TEMPERATURE OF THE SEA.—The thermometers employed for measuring deep sea temperature, and used throughout the "Porcupine" dredging expedition, were of a pattern invented for the purpose by Professor Miller, and made by Mr. Cassella. In all previous researches of the kind ordinary thermometers have been used, and these are not only very liable to fracture, but they also rise under pressure, and the readings from them require correction on this account. The Miller-Cassella thermometer, on the other hand, was tested under a pressure of 3 tons to the square inch (corresponding to that of an ocean depth of 2,400 fathoms), prior to the departure of the expedition, and showed no more change than a rise of about 1 degree, which was due to the actual increment of heat arising from the pressure itself; while so strong were the instruments that two of them were in constant use, without injury, throughout the whole of the expedition. The temperature was taken both by serial and by bottom soundings; the former being repeated every

50 fathoms, or even more frequently, down to a depth of 300, and every 100 fathoms at greater depths. The surface temperature varied a good deal with the differences of latitude and season; but, when high, declined rapidly, and was lost at about 100 fathoms. From hence, in deep water, there was a rapid decline to about 1,000 fathoms, at which a temperature of about 38 deg. was found; and at 2,435 fathoms there was a slight further fall to 36.5 deg. Compared with this comparatively elevated temperature, it has been found that the deep sea temperature in the Arabian Gulf, and even under the equator, is very low, falling to about 30 deg., or even lower; so that the general temperature of the deep tropical seas is less than that of the North Atlantic basin. On the other hand, the bottom temperature of certain parts of the channel between the Faroe Islands and the north of Scotland, sunk to as low as 30 deg., while at the same depth in adjacent localities it was as high as 43 deg. In the colder area it was found that the temperature fell rapidly between 150 and 300 fathoms, to remain almost stationary below the latter depth; and the general result of the thermometric observations was to show the existence of a stratum of ice-cold water from 300 fathoms downwards; a stratum of warm water for about 150 fathoms from the surface, and a stratum of intermixture between the other two. The cold area occupied nearly the whole of the actual channel between the Faroe Islands and Scotland; but a higher bottom temperature was found along the east side of this channel, near the so-called 100 fathoms line, which marks the commencement of the ascent to that plateau of which the surfaces form the British Islands.—*The Engineer.*

Varnish for Iron.—The following is a method given by M. Weiszkopf, of producing upon iron a durable black shining varnish:—"Take oil of turpentine, add to it, drop by drop and while stirring. strong sulphuric acid until a syrupy precipitate is quite formed, and no more of it is produced on further addition of a drop of acid. The liquid is now repeatedly washed with water, every time refreshed after a good stirring, until the water does not exhibit any more acid reaction on being tested with blue litmus paper. The precipitate is next brought upon a cloth filter, and, after all the water has run off the syrupy mass is fit for use. This thickish magma is painted over the iron with a brush; if it happens to be too stiff, it is previously diluted with some oil of turpentine. Immediately after the iron has been so painted, the paint is burnt in by a gentle heat, and, after cooling, the black surface is rubbed over with a piece of woollen stuff dipped in and moistened with linseed oil. According to the author, this varnish is not a simple covering of the surface, but it is chemically combined with the metal, and does not, therefore, wear off or peel off, as other paints and varnishes do, from iron."

A New Method of Casting Metals.—Until recently there has been for a long time no material improvement in the methods and processes of casting metals. Moulds of sand into which the molten metal is poured, producing a rough casting, requiring to be finished by hand, is the process which, for generations, has been in general use. The nicer and better kinds of work involve a large expense in the labor of finishing after the casting is taken from the mould, and there is a very large number and variety of metallic articles, both of an artistic and economic character, which could not be cast at all, but each had to be wrought separately by the slow and tedious process of the engraver.

The recent inventions of Charles and Michael Smith, introduced with complete success into practical operation by the Metallic Compression Casting Company at their foundry in Somerville, near Boston, promise to result in an entire revolution in the metallurgic art, so far as casting is concerned.

By the process covered by the patents of the Messrs. Smith, the metal is taken from the mould, not with a rough surface, as in all the heretofore known modes of casting, but as smooth and perfectly finished as a coin or medal struck by a die, and this at no considerable addition to the cost of casting by the old process. It is true that almost every step in the process as invented by the Messrs. Smith, is totally different from the old, but at no greatly enhanced cost.

The company are now actually at work producing for the market, house and car trimmings, such as knobs, hinges, escutcheons, bell pulls, dies for printing wall paper, and for bookbinders, and a variety of articles which, until these inventions, could be produced by hand, but by the new processes are turned out with equal if not greater facility as common rough castings.

Experiments entirely successful have been made in casting stereotype plates, printing types, medallion heads of Corneille, Schiller, Gœthe, and a copy of the famous Wellington medal, the dies for which occupied the artist 11 years in their execution. The copy cast by the Compression Casting Company came from the mould as perfect in finish as if struck by the original die. These experiments show that, no matter how delicate or elaborate the style of the work, it can be cheaply and with perfect accuracy produced by this process. Two specimens of work seem conclusively to establish these facts—one a bas relief representation of the battle of Bunker Hill, after Trumbull's famous picture, containing over fifty figures, originally modelled in wax, cast in hard metal by Mr. Smith by the compression process. Several leading European founders declined the work, the artist requiring a guaranty of payment of $5,000, the value of the model, in case of injury. The other was a specimen of the wheels used in cancelling stamps, with the edges lettered and figured. The moulding of these wheels excites the admiration of the spectator, as he observes the simplicity and efficiency of the work and the satisfactory character of the result.—*Exchange.*

Action of Sunlight on Sulphurous Acid.—We know that plants, under the influence of the sunlight reduce within their substance carbonic acid and water to organic compounds and organized tissues. We know further, that the albuminous parts as well as some essential oils of plants contain sulphur, which doubtless comes from the sulphates contained in the soil.

As regards this reduction of sulphuric acid in the plants, it seemed to me of some interest to try whether the sunlight possesses any reducing power upon the oxygen compounds of sulphur outside of vegetable tissues. For this purpose I exposed diluted sulphuric acid, solutions of sulphates, sulphites, and aqueous sulphurous acid, under various conditions, in sealed tubes, to the

sunlight of last summer. With sulphurous acid only did I notice any change; and even the tubes containing this remained *clear during two months*, but after that time a change set in which slowly increased, and sulphur was deposited in a finely divided state.

Sulphurous acid was thus gradually reduced to sulphur, but *oxygen was not liberated;* another part of the acid having been oxidized by it to sulphuric acid. It seems very singular that such a period (two months) was required to initiate this change; and it would appear that a previous absorption of a great amount of light was necessary to the separation of the first atom of sulphur, which was followed then, however, by more atoms at shorter intervals.—*American Gas Light Journal.*

PHILOSOPHICAL SOCIETY OF GLASGOW.—CHEMICAL SECTION.—At a meeting of the section an interesting paper was read by Mr. W. R. Hutton, manufacturing chemist, on "The Chemistry of Coal Smoke." Mr. Hutton's object was to direct attention to the chemical ingredients of smoke as determined by the analysis of soot, and to suggest a means of thoroughly avoiding the production of smoke, both in domestic fireplaces and in ordinary steam-boiler furnaces. Very elaborate analyses of London and Glasgow soot were given. Tar and oil were found to the extent of from 15 to 18 per cent., 2.8 per cent. ammonia, from 4.6 to 7.9 per cent. of sulphuric acid, and from 14.4 (in London soot) to 25.7 (in Glasgow soot) of sand. It was not improbable that the last-mentioned ingredient was present, in part at least, as an adulterant. Mr. Hutton expressed himself strongly in favor of distilling the raw coal before using it as fuel, and stopping the distillation shortly before the volatile matter is all removed. There would thus be left what Mr. Hutton calls *soft coke*, containing all the fixed carbon, the ash, and enough of volatile matter to render the coke inflammable, but not to produce soot. The author assumed the case of a town consuming 2,000 tons daily, and said that if the coal were distilled before being used as fuel, as he suggested, there would be produced about 1,400 tons of soft coke, 40,000 gallons of crude oil, 30,000 gallons of ammoniacal water, and 6,000,000 cubic feet of hydrocarbon gas. Taking the coal at 5s. per ton, and the labor at 1s. per ton, there would be a clear gain of £142, as the coke would have the same heating power and therefore the same value as the raw coal, while the crude oil would bring £167, and the ammoniacal water £75 additional.—*Engineering.*

QUICKSILVER AND IRON.—The difficulty of imparting to iron a complete and uniform coating of mercury by dipping it in a solution of mercury is well known. The process may, however, be very easily accomplished by cleaning the iron first with hydrochloric acid, and then immersing it in a diluted solution of blue vitriol mixed with a little hydrochloric acid, by means of which it becomes covered with a slightly adherent layer of copper, from which it must be freed by brushing, or rubbing with sand paper and washing. It is then to be brought into a diluted solution of mercurial sublimate mixed with a few drops of hydrochloric acid. The article will now be covered with a layer of mercury, which cannot be removed even by hard rubbing. This layer of quicksilver protects the iron from rust, especially if it be washed with spirits of salammoniac after the amalgamation. Articles for the laboratory, and for other purposes, coated with quicksilver in this way, and allowed to be exposed with similar articles not so protected, retain their lustre perfectly, while the others become covered with rust. This same process is especially applicablo to the coating of the steel or iron instruments for which oil is generally employed, and will probably be found to resist the injurious effect of moisture much more perfectly than the oil.—*Iron Age.*

EFFECT OF SUNLIGHT ON GLASS.—M. Bontemps, the managing director of the celebrated crystal glass works of Choisy-le-Roi, says: "Within three months after exposure to sunlight, the best and whitest glass made at St. Gobain is turned distinctly yellow; extra white glass (of a peculiar manufacture) becomes even more yellow, gradually assuming a color known as *pelure d' oignon;* glass containing 5 per cent. of litharge is also affected, but far less perceptibly; crystal glass made with carbonate of potassa (the other varieties referred to contain carbonate of soda), litharge, and silica, is not at all affected. English plate-glass, made by the British Plate-Glass Company, and exhibiting a distinctly azure-blue tinge, remains also unaffected. The author attributes this coloration, which begins with yellow and gradually turns to violet, to the oxidizing effect of the sun's rays upon the protoxides of manganese and iron contained in the glass.—*Quarterly Journal of Science.*

OXYGEN GAS.—The manufacture of oxygen gas on a commercial scale is increasing in Paris. Mr. Fowler, who has described one of the factories, says that 500 pounds of manganate of soda furnish 2¼ cubic yards of oxygen every hour. The charge is placed in a retort and superheated--steam passed over it; in five minutes all the oxygen is extracted from this quantity of the salt. Hot air passed over this residue for five more minutes restores all the oxygen given up, and the result of an hour's continuous work, or six extractions of oxygen and six re-oxidations, is 2½ cubic yards of oxygen. This oxygen, when it issues from the gasometers, contains about 15 per cent. of nitrogen; but, by letting the first portions escape, the quantity of this mixture can be reduced to 2½ per cent. M. du Mothay affirms that one ton of manganate of soda will yield 100 cubic yards of oxygen daily, or more than 36,000 per year; and this without having to renew the salt once.—*Quarterly Journal of Science.*

THE MOON'S HEAT.—According to M. Baille, the moon's surface emits as much heat as a cube filled with water, covered with lamp-black, having a surface of 6.5 square centims., and placed at a distance of 35 metres from the thermo-electric apparatus employed by the author in his experiments.

CIVIL ENGINEERING IN AMERICA IN 1831.—When it was proposed in 1831 to build a railroad from East Boston to Salem there was not a civil engineer in Massachusetts of sufficient practical knowledge to make a survey. Lieutenant Vinton, of the United States Artillery, stationed at Fort Independence, was detailed for the duty.

ERRATUM.—On page 234, 21st line from bottom, instead of "Bajle," read "Bogle."

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COAL WASHING.

BY ARTHUR BECKWITH, MEMBER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, GRADUATE OF THE ECOLE IMPERIALE CENTRALE DES ARTS ET MANUFACTURES, PARIS.

IMPURITIES OF COAL.

A perfectly pure seam of coal, that is of coal which leaves by combustion an insignificant amount of ash, is very rarely found.

If we consider the origin and formation of coal, it will be seen that, besides the incombustible materials contained in wood and vegetable fibre, and which are, in part at least, found in the coal, there are many impurities foreign to these, which are introduced during the process of transformation of woody fibre into coal.

Whether a coal seam is derived from vegetation *in situ* or from *drifted* vegetation, the addition of foreign sedimentary matter, formed in successive deposits from the water holding it in suspension, is almost universally observed.

The denomination of *splent* coal, given to a hard laminated variety of bituminous coal, is derived from its splitting or *splenting* into separate laminæ, arising from its mode of formation. Of the structure of the Appalachian coal, which covers such a large area in the United States, Professor Roger says: "Each bed is made up of innumerable very thin laminæ of glossy coal, alternating with equally minute plates of impure coal, containing a small admixture of finely divided earthy matter."

An examination of a series of tables showing the composition of the ash of wood, peat, lignite, coal, and graphite, is instructive.

The ash of wood reveals by analysis the presence of sulphates and phosphates of lime and oxide of iron in moderate proportion, of a large amount of lime, magnesia, and potassa, and of a very little silica, alumina, soda, oxide of manganese. The ash of peat and of lignite contains the same elements, but a change is observed in their relative proportions. The amount of potassa is found to have diminished, whilst silica, oxide of iron, alumina, and sulphur have increased. The ash of many coals has been analyzed. It contains in general a large proportion of silica, alumina, oxide of iron, sulphur, with a greatly diminished amount of lime and magnesia.

Finally, the ash of various graphites is found to consist generally of as much as 90 per cent. of silica and alumina, and 6 to 10 per cent. of oxide of iron, with a small amount of lime, magnesia, and alkalies.

The gradual and continuous change in the nature of the ash confirms the theory which attributes most of the impurities of coal to foreign sedimentary deposits, for we observe a gradual diminution of these elements of the ash of plants, which, like the alkalies, are very soluble or enter easily into soluble combinations, and, on the other hand, an increase of elements,

such as silica, alumina, and iron, which enter largely into the composition of clays and of most soils.

Even the best mineral coal reveals by analysis traces of sulphur. The sulphur smell ordinarily perceived in coal fires is owing to this. The sulphur is found in combination with iron, forming pyrites, or in the shape of sulphate of lime, magnesia, etc., in scales. The pyrites are disseminated in coal beds in nodules or seams of great tenuity. They are sometimes so small as to be invisible to the naked eye, although abundant. At other times the yellow crystals of pyrites or bi-sulphide of iron are visible. By exposure to air, yellow spots appear on the surface of certain coals; these are due to the oxidation of the pyrites. The water in some coal mines is so highly charged with sulphate of iron as to be very destructive to rails and boilers. The red color of the ash of many coals is due to the presence of oxide of iron, which comes chiefly from the pyrites.

Besides the above impurities, bituminous schist, arsenical pyrites, carbonate of iron, in scales, are found. Accidentally various other metallic sulphides, galena blende, copper pyrites, sulphide of mercury, have been found. Rivot has detected the presence of a heavy proportion of phosphate of iron in some bituminous schists which accompany coal.

All these impurities which exist in the coal in the shape of bands or scales generally apparent to the eye, constitute the ashes and clinker left by combustion. The chief source of clinker is the carbonate of lime and pyrites.

Besides the impurities contained in the coal seams, most coals when ready for market contain fragments of wall rock which become mixed with it during the operation of mining. When the wall rock, or strata immediately contiguous to the coal, is friable, these fragments are often in such abundance as to injure seriously the quality of the coal.

ADVANTAGES OF COAL WASHING.

When a coal basin produces coal which contains but a small average percentage of ash, and when, at the same time, there is but little slate or schist interstratified in the coal seams, and when the roof and wall rocks are firm and solid, it frequently happens that the coal on leaving the mine is sufficiently clean to be delivered at once for consumption. This is oftener the case in England than in France, where coal washing has been first practised on an extensive scale; but it is also true that the advantages of using pure fuel have been the better appreciated by the consumer in France.

The first trials of coal washing were made some thirty years ago at St. Etienne; to-day the operation is carried on by hundreds of thousands of tons, and usually accompanies the manufacture of coke, of pressed fuel, or the use of raw slack coal.

A simple calculation shows that when the price of coal is at all high the consumer will find it to his interest to pay for the cost of washing. Some industries demand imperatively the use of pure fuel.

The injurious action of the sulphur contained in the fuel used in blast furnaces for smelting iron or in puddling furnaces need not be dwelt upon.

Many coals when deprived of their impurities will coke, although they cannot be coked without washing; the quality of every description of coke may be greatly improved; different qualities of caking and non-caking coals may be *mixed*, purified, and coked, thus incorporating non-caking coals into solid coke.

Carbonate of lime and pyrites, the principal sources of *clinker*, are removed by washing, so that the clinker may be greatly reduced. The labor in attending boiler fires due to the presence of clinker may be spared. Whenever the transportation of coal is expensive, as in steamers, the removal of 10 per cent. or more of ash is a serious consideration.

This industry is also important to gas companies, for gas free from sulphur and a more valuable coke may be produced. In the manufacture of brick-coal or patent fuel, the operation of washing allows the use of inferior slack coal, and gives a better product.

Much of the bituminous coal of Pennsylvania and Ohio is impure. The Illinois coals contain 1 to 37 per cent. of ash (Geological Report), and the joints are sometimes filled with foreign matter containing much sulphur. To the impure coals of these and other States will the coal-washing operation be of particular benefit.

Many seams of coal containing impurities mechanically mixed are at present discarded for purer seams which lie deeper

beneath the surface or at greater distances from market. The coal of those seams can be thoroughly cleansed of these impurities by a proper washing process, and it will then become merely a question of cost of washing per ton, against diminished mining and freight expenses on account of a more available location and proximity to market, to render many of these impure seams as valuable and even more profitable than purer ones.

The cost of coking, which limits so seriously the value of many coal seams, is susceptible of great reduction. The methods of coking hitherto practised in America give very inferior economic results when compared to European processes. This arises from the improper construction of our coking ovens, and, singularly enough, from the lack of labor-saving apparatus, in both of which there is room for simple improvements. With regard to coal washing, the "London Engineer" says:

"Coal washing, however, is not as yet sufficiently known and appreciated in this country (England). Continental collieries are far in advance in this respect, and a great deal could be learned and *must* be learned from them by our coal-masters before long."

SEPARATION OF THE IMPURITIES BY WATER.

In the separation of the impurities contained in coal by the action of water, this liquid acts in three different ways: By *differences of specific gravity*, by *solution*, and by *mechanical mixture*.

1st. By the last is understood an intimate mixture of a liquid and fine particles of matter, which are not, properly speaking, *dissolved*, but merely carried mechanically in suspension, and which will generally deposit themselves when the liquid is at rest. The matter separated in this way, forms a "slime" or "schlamm," which consists of a considerable amount of very fine coal together with many particles of fine clay, shale, and earthy ingredients. When this slime is collected in proper deposit basins and dried, it can be used as inferior fuel, thus economizing the fine coal dust which is usually lost.

2d. The substances separated from coal by *solution* in water are many, as coal is completely insoluble. What these substances are may be readily seen by inspecting a table of solubility. All sulphates, for instance (with the exception of those of BaO, SrO, PbO, not often met with in coal), are soluble in water, so that the separation of those injurious substances and of others by solution, affords a ready means of purification.

3d. The chief action depended on, however, in coal-washing machines is the difference between the specific gravity of coal and its impurities. The specific gravity of coal and lignite varies from 1.2 to 1.46, water being 1.0, while that of the impurities is considerably greater, as follows:

Clay slate (specific gravity)...	2.6
Mica slate..................	2.6 to 2.9
Limestone and dolomite......	2.5 to 3.0
Sand, quartz................	2.6 to 2.7
Phosphate of lime............	2.7 to 3.3
Carbonate of iron............	3.7 to 3.9
Iron pyrites, yellow and white.	4.7 to 5.0

As the impurities of coal are completely disseminated throughout the mass, it must first be crushed sufficiently to allow them to be separated. When a mass of slack or crushed coal is submerged in water in motion, all the clean coal, being lightest, finds its way to the upper layers, while the impurities, being heaviest, accumulate below.

The form and size of the fragments have a great influence on the separation. The resistance which a liquid medium opposes to bodies moving through it, impelled by a given force, is proportional to the *surface* which they present; and for bodies presenting the same surface, the velocity increases with the *weight*. Now, the weights of two bodies of same form and density are *as the cubes* of one of their dimensions, while the surfaces are *as the squares*. It is then clear that, to effect an easy separation by specific gravity, the bodies to be separated should be of the same size and form.

It is easy by the use of proper sizing apparatus to obtain fragments of uniform size, and thus to realize the first condition which is essential to perfect and prompt separation.

With many coals no other precaution than sizing is necessary, as they have a natural tendency to be reduced by crushing into *cubical* fragments, consequently of the same form. But other coals are of a slaty nature, or abundantly interstratified with thin seams of shale, schist, slate, etc.

When these coals are crushed the pure parts break up into small cubes, but the impure parts and the thin layers of shale and schist break up into *flat* fragments. A simple fall through water will not separate these bodies, even when uniformly sized, for, the impelling force being the weight, the weight of a cubical fragment of pure coal will often exceed that of a flat fragment of shale presenting the same surface and greater density. An additional means of separation is then required, and is obtained by the use of a *lateral* or nearly horizontal current imparted to the water as in *step-washing* and in some other machines. This horizontal current separates the cubical coal from the flat shale for two reasons: the coal presents more surface to the action of the current than the shale, which presents its thin edge to the stream; this, together with its greater weight, promptly deposits the shale, while the coal is carried away. From inattention to this requirement disappointments have sometimes arisen, which might have been obviated by the choice of a machine adapted to the nature of the coal.

A further advantage derived from properly sizing the coal, arises from quicker washing. The production of a "jigging machine" is proportioned to the *number of effective strokes* per minute. To be effective, each stroke must last long enough to give the impurities time to settle. This time is shorter, and also more uniform, when the fragments are all of equal size.

CRUSHING AND SIZING.

To effect a perfect separation it is necessary then to crush and size the slack coal before washing. This operation is practised in many coal-washing establishments, and is particularly required when the coal is slaty.

In crushing, it is desirable to produce the least quantity of stuff finer than is intended, for this dust obstructs the crushers, and allowance must be made for the presence of hard stones in the coal. The coffee-mill principle is not well adapted to fulfil these conditions. Crushing rollers, geared together, do not work well unless the teeth are sufficiently long to allow of a variable space between the cylinders; the play thus allowed produces loss of power by friction. It is best to use crushing rollers commanded by separate belting for each. These rollers, as in Bérard's machine, are grooved in two directions, forming rows of quadrangular teeth with rounded tops, which break up the schist effectively. In Bérard's machine, one of the cylinders is free, and held by a spring. A large diameter increases the hold of the crushers. A pair of cylinders of 20 in. diameter, 36 in. long, making 60 revolutions per minute, will crush 10 tons of coal per hour.

The crushing rollers may be maintained in contact as in the rollers for crushing ores, either by screws, a lever and a counterweight, or by springs of metal or india-rubber. The first method is objectionable and causes breakages. The second works very well in Cornwall. Bérard uses the third. A system has been devised by Mackworth, in which the rollers are conical and connected by a number of india-rubber bands strongly stretched. A compound cord of india-rubber 3 in. in diameter composed of 144 small cords when stretched to double its natural length gives a strain of 3 tons, which is exerted to keep the rollers in contact. The coal is supplied to the rollers from a feed hopper.

The *sizing* is performed by passing the coal through sieves, which are either cylindrical as in the *sizing trommel*, or plane, as in the *swing sieve*. The trommels do not perform much work, unless their diameter is considerable; an increase of velocity produces adhesion of the coal to the sieve and performs less work. Shaking sieves, strongly inclined and superposed, are better adapted to a large production. The sieves are made of wire or of punched screens, that is, perforated metallic plates. Evrard has perfected a system of horizontal annular sieves which turn on a vertical shaft; the coal is swept off each sieve by stationary curved arms.

A size of 0.7 to 0.8 in. in diameter is well adapted to washing. The size, however, should be determined in each particular case by the use to which the coal is to be put, and by its tendency to form a paste.

PRINCIPLE OF COAL-WASHING MACHINES.

We have seen that the difference between the specific gravities of coal and its impurities, and the solubility of some of these, allow of their being separated *by the action of water*, when they are reduced

to a proper size. Machines for washing coal may be divided into different classes according to the mode of action of water in each.

First class.—The coal is submitted to *a continuous stream* of water upon inclined tables, as in the *step-washing* of ores. The tables are inclined against the stream and arrest the heavier impurities, while the clean coal, being lighter, is carried on to a platform where it is deposited and the water drained off.

Second class.—The mode of action in this class of machines consists in forcing the water *alternately up and down* through the mass of coal as in the *jigging process* for washing ores. The coal is charged upon a sieve, and the water acts upon the coal from below through the sieve. The jigging motion is imparted by hand or machine, either to the water, in which case the sieve is stationary, or to the sieve while the body of water remains stationary, as in the jigging machines first used for ores. In either case the stones and denser bodies remain on the sieve while the coal accumulates above and is carried off, either by a stream of water devoted to that purpose, by laborers who shovel it away, or by various mechanical devices. The impurities which accumulate upon the sieve are removed at given intervals of time in various ways.

Third class.—In these machines *an intermittent stream* of water, *constant in direction*, acts upon the coal from below, through a sieve. In the jigging process the water *oscillates* and returns upon itself at every stroke, while in the third class of machines the water never retraces its steps, and the motion is properly *pulsatory*. The requisite pulsatory motion is generally obtained by a pump.

Fourth class.—The coal is submitted to a slow and *continuous upward stream* of water, which, aided by a rotating arm, carries the clean coal out upon a perforated plate where it is drained, while the shale and dense impurities fall slowly through the ascending current of water, and accumulate in a shale box, where they are evacuated. The stream of water acts vertically in this class, while in the first class it acts horizontally.

The Bérard, Revollier, Kladno, Edwards and Beacher, and Evrard machines belong to the second class.

The Meynier, Ractmadoux and Coppée machines belong to the third class.

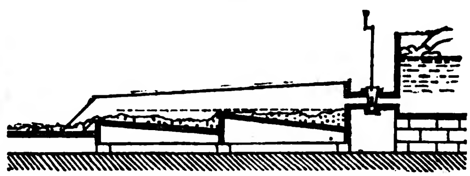
Mackworth's machine is of the fourth class.

For much of the following information relating to these machines, I am indebted to Mr. Burat, Professor at the Ecole Centrale des Arts et Manufactures, and to various papers on the subject by Messrs. Lebleu, Petitgand, Ronna, Darlington, etc.

STEP-WASHING.

(Caissè à eau Courante, Washerde.)—In 1838 Ractmadoux described a method then used at the mines of Bert, and which, as far back as 1826, was used in the valley of Tarand, near Dresden, for purifying slack coal. A continuous stream of water from a superior reservoir is directed upon a flat chest, the bottom of which is formed of two steps inclined 1.5 in. per ft. against the stream. The second step is lower than the first, and is

FIG. 1.



STEP-WASHING.

succeeded by a table of wickerwork, or a perforated metallic sheet, upon which the cleansed coal is drained. A low flat board across the upper end of each step serves as a dam to arrest the slate, stones, and denser bodies; when these have accumulated sufficiently upon the steps, the washing is interrupted for a moment and they are shovelled away.

The above cut and the succeeding ones are reduced from more complete drawings, and merely illustrate the principle of the various machines.

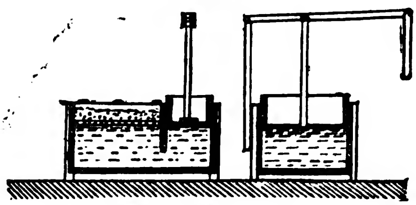
HAND JIGGING MACHINE.

The jigging process was applied to purifying coal at the St. Etienne collieries as early as 1837. The coal of this basin in the centre of France is so frequently interstratified with slates, etc., as to require imperatively to be cleansed.

A wooden hutch or chest, measur about 4 by 6 ft. and 3 or 4 ft. high, is

divided into two compartments. In the first compartment a rectangular wooden piston measuring 2 by 4 ft. is acted upon through a piston rod and hand lever; this piston communicates an oscillating

FIG. 2.



HAND JIGGING MACHINE.

movement to the water under it, which is at once transmitted through a rectangular side opening 1 by 4 ft. to the water in the second compartment. Across the second compartment, about 6 in. from the top, is a sieve or grating, upon which the coal is charged. The area of this sieve is double that of the piston, or 4 by 4 ft.

Successive charges of coal are made upon this sieve, cleansed by jigging, and shovelled from the surface. After several charges, the sieve is taken out and the refuse slates, etc., which have collected upon it, are thrown away. One man can wash ⅜ to ½ a ton per day of 10 hours in this machine, which is particularly adapted to very slaty and impure coals. It will be shown later how Revollier imitates the peculiar hand motion of this machine.

BERARD'S MACHINE.

This machine belongs to the second class. In 1848 Mr. Bérard invented a somewhat complicated machine, which has since been simplified into its present form.

It consists of a pair of crushing rollers, an elevator formed of an endless chain with buckets, a classifier formed of shaking tables, a cistern and piston, an agitator, a chest for deposits, and water tanks.

A power of 5 to 6 horses is required by the apparatus, which will purify 80 tons of coal per day of 12 hours. The slack coal used is passed through the crushers, which are provided with cast-iron coverings grooved in two directions so as to form a number of quadrangular teeth with slightly rounded tops. These double grooves break up the slate contained in the coal more effectively than single grooves would. The distance between the rollers can be altered to suit the hardness of the coal.

From the crushers the coal falls into a pit of masonry formed like an inverted quadrangular pyramid, three faces of which are inclined at 45 deg., and the fourth vertical. The buckets of the elevator carry this crushed coal to a higher level and discharge it into the classifier. So as to obtain regularity of feed, the buckets as they rise pass close to a board which equalizes their contents and throws the excess of coal back into the pit.

The classifier, which receives the coal from the buckets, is a rectangular sheet-iron chest containing stages of perforated plates, the apertures in which are 0.8 to 1.2 in. in diameter, and decrease in a downward direction. A shaking motion is imparted to these tables through a cam movement, or a rapid reciprocating motion is produced by a direct connection with a bent axle, commanded by cog gearing. The classifier is freely suspended by two or three pair of articulated handles turning on fixed axles.

The fine coal which has passed through the classifier falls into the washing cistern, whilst the larger pieces return along an inclined channel to the crusher.

The washing cistern consists of a rectangular cast-iron chest, the bottom of which is mostly inclined at 45 deg. A cast-iron frame is firmly fixed near the top of the cistern with a slight inclination of 3 in 100. Across this frame is secured a perforated plate made either of zinc or copper. The size of the holes varies according to the kinds of coal.

Upon one side of the cistern is bolted a vertical cast-iron cylinder, the bottom of which is curved so as to place the cylinder in communication with the cistern through an aperture in its side. A piston fitting into this cylinder receives a rapid reciprocating motion, imparting an upward and downward "jigging" motion to the water in the cistern, which acts through the perforated plate upon the impure fine coal, carrying the pure coal upwards, and separating the denser impurities. These accumulate upon the grate, and by means of a partition and small flood-gate these schists, pyrites, etc., are discharged into a pocket from whence they can be emptied into wagons. The pure coal carried upwards at each stroke

flows over one edge of the cistern into a trough, where a chain and buckets elevate it and discharge it into a hopper. This hopper is at a sufficient height to allow the coal to be delivered through a bottom door into cars.

A man-hole is provided on one side of the cistern, and an opening at the foot of the inclined bottom, through which the mud which accumulates there can be emptied.

A separate feed pump supplies the cistern with a determined amount of water.

Bérard's machine is used in many localities in France, Belgium and Germany, also in England at the Whitehaven and Fence-Houses collieries. It is somewhat complicated, and has been improved upon.

The first cost of the machine to produce 80 tons a day is in France $4,400 gold. Add masonry, water pipes, belts, sheds, for $2,000 more. Total, about $6,400. The direct cost of washing, including labor of 1 man and 1 boy, oil, repairs, and interest on first cost, is estimated at 5 cts. per ton.

The loss produced by the percentage of impurities varies with the coal.

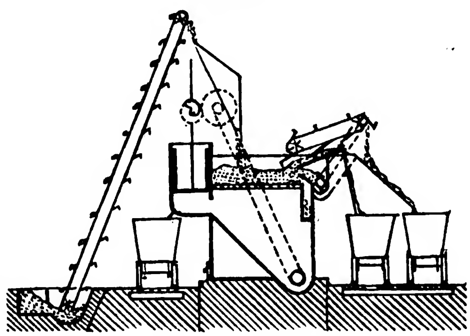
REVOLLIER'S MACHINES.

Mr. Revollier, known for his coal-pressing machine, has also perfected two coal washing machines, analogous to Bérard's, and acting by the jigging process.

First Machine.—The piston is of wood and square instead of round, and fits loosely in its box. The washing cistern is made of sheet-iron, and presents two compartments; a bucket and endless chain plunges into the coal compartment and extracts the clean coal; a wheel and buckets removes the schist through a side opening. The same water is used over many times.

Second Machine.—This machine is an improvement on the preceding one, and on Bérard's. The sorter of Bérard is suppressed. An endless chain and buckets raises the slack coal 20 ft. from a pit and discharges it into a hopper over the washing cistern. The surface of perforated sheet measures 38 by 56 in. The coal slack cleansed is separated into two qualities; the upper or first quality is raked off the surface by an endless chain with rakes, and falls into a shoot 4 ft. long, which discharges it into a car. The second quality of coal coming from the medium level of the washed mass, runs over the edge of the cistern into a trough, where a horizontal screw carries it to a small bucket elevator which raises it 6 ft. and empties into a shoot leading to a car. Finally the schists and impurities pass from the lowest level of the washed mass into an inclined pocket, at the foot of which a screw carries them horizontally to a bucket elevator which raises them 12 ft. and discharges them into a car. The total surface occupied by the apparatus is comprised within an area of 8 by 25 ft. The amount of coal washed per day is 60 tons.

Fig. 3.



REVOLLIER'S MACHINE.

These machines are used in the centre of France, in the basin of the Loire; the coals of this basin are more impure and harder to clean than those of Belgium and the Northern basin. To separate these very slaty coals the *hand jigging* process is the most effective, as the intensity of the jigging can be readily varied to suit the separation. Thus at the start the layer of coal should receive a sudden and rapid impulse which carries the coal and schist upwards, whilst the stroke is then slackened, and the schist settles slowly down and the coal remains in suspension.

Mr. Revollier imitates this motion by giving a height of 30 in. and considerable weight to the piston. The piston is raised slowly by a pair of eccentric cams and falls back suddenly, impelled by its own weight, and sometimes by a spiral spring. This gives the sudden impulse required to the water. The diameter of the piston is 30 in., and it fits loosely in the cylinder.

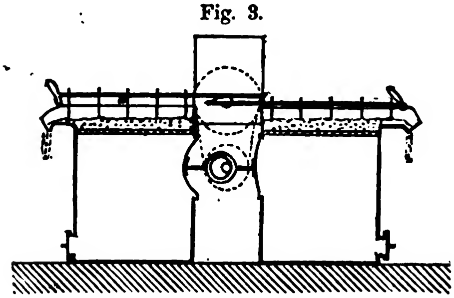
KLANDO MACHINE.

Also of the second class. At the Kladno Iron Works, Austria, the coal is purified by washing on a large scale. After being ground in a species of enlarged coffee mill to a fine powder, the coal dust is discharged into an inclined sieve which sorts the different sizes and discharges them upon a series of rocking sieves placed in water tanks. The rocking motion of these sieves alternately brings the layers of coal spread upon them above and below the water and effects the separation as in the jigging process. A constant current of water, kept running through the whole apparatus, carries away the finest dust and "schlamms" from the coal, and deposits them in a slime basin, as in Coppée's apparatus, while the clean coal is removed from the upper layers on the sieves. It will be observed that in this machine the body of water is comparatively stationary, whilst the sieves receive the jigging motion as in the first jigging machines devised for washing ores.

EDWARDS AND BEACHER'S MACHINE.

Belongs to the second class. In this machine two rectangular cisterns are placed upright a few feet apart. On the sides of the cisterns facing each other are two circular apertures closed by flexible discs or diaphragms of leather, to which a horizontal reciprocating motion is imparted by means of an eccentric on a horizontal shaft. This shaft is driven by a belt and pulley, or by a steam-engine attached directly to it. The action of the flexible diaphragms imparts to the water in the cistern the requisite jigging motion.

Fig. 3.



EDWARDS AND BEACHER'S MACHINE.

Across the upper end of the two cisterns are stretched perforated plates upon which the coal to be cleaned is fed through a hopper, which also connects the two cisterns.

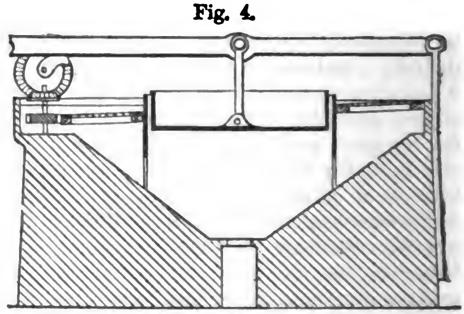
Above the driving shaft is a smaller one driven at a slower rate by cog gearing; eccentrics or cranks communicate a horizontal reciprocating motion to a set of scrapers above each cistern. These are so arranged as to remove the upper stratum of coal, which is the cleansed portion, and discharge it over the edge into cars. When the schists, pyrites, etc., have accumulated on the screens to a sufficient depth, the scrapers are thrown out of gear, and these impurities are raked off. One machine of two connected cisterns will wash 30 tons of coal per diem.

EVRARD'S MACHINE.

Belongs to the second class. This machine is a modification of the preceding one and adapted to operate at once upon a larger quantity of coal. Mr. Evrard gives to the sieve the form of a ring of 33 ft. exterior and 19.6 ft. interior diameter.

This annular sieve is placed across the top of a conical basin built up with solid masonry walls. The centre of the ring is occupied by a vertical cast-iron cylinder, in which fits loosely a hollow cylindrical piston 18.4 ft. in diameter. The surface of the piston is 270 square ft., or just one half that of the annular sieve. This sieve is not horizontal, but inclines 3 in 100; so that whilst the upper end is 2 in. above the level of the water in the basin, the lower end dips 10 in. below the level.

Fig. 4.



EVRARD'S MACHINE.

The fine coal is charged upon the upper end of the sieve through a hopper opening a few inches above the water level. A rotary motion of one revolution in 5 minutes is imparted to the sieve, so

that in this interval of time the coal is carried slowly through the water and is submitted to the jigging process at depths varying successively from 0 to 10 in. and back again to 0. As the coal emerges from the water towards the end of the turn, it is scraped off by a series of curved stationary arms. The first pair of arms takes off 1.5 in. of the surface coal, which is cleanest, and does not contain more than 3 or 4 per cent. of ash. The second pair of arms dips 3 in. under water, or deeper than the first, and collects a medium quality of coal containing about 6 per cent. of ash. The third pair of arms is movable, and dips 3 to 4 in., removing a layer consisting of an intimate mixture of coal and schists of very variable percentage of ash. Finally, the fourth pair of arms, also movable, scrapes the bottom of the sieve and removes the stones, schist, etc., which have accumulated during a number of revolutions. Whenever the deposits of stone and schists attain a thickness of 2 in. they appear at the third pair of arms, which are then thrown out of gear, and the fourth pair is brought into play. One man attends to these arms and to loading the refuse in cars.

The bottom of the basin is in the shape of an inverted cone. A bottom door allows the slime which accumulates there to be dropped into cars moving on rails, in a gallery running through the masonry. The sieve is made of perforated metallic sheets fastened to an iron frame; the outer rim is provided with cogs; two pinions of equal size command the circular rack, so that if one pinion breaks, the operation is not interrupted. Conical horizontal rollers and cylindrical vertical ones maintain the sieve in its place. All these organs are submerged in water and wear out very slowly.

The piston is commanded by a lever 40 ft. long and an eccentric cam, and gives 20 strokes a minute.

A 4-horse power engine moves the sieve and piston. A second engine also of 4-horse is required for the sorter, and bucket elevator which supplies the hopper.

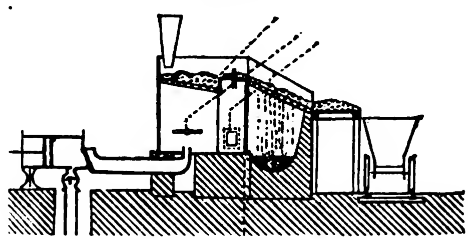
This machine washes 400 to 500 tons of coal per day.

Mr. Evrard has established one of these machines at the collieries of La Charotte; the first cost is £20,000 gold, and the cost of washing 5 cts. per ton of coal.

MEYNIER'S MACHINE.

This machine belongs to the third-class. Mr. Meynier, upon studying the jigging process, considered that the downward or return current of water in the jigging process is prejudicial to the separation of substances in the order of their densities, and submitted to the "jigging" motion a pulsating motion, *i. e.*, an intermittent flow constant in direction, and never returning upon itself. There being no return current, the finer particles of coal are not carried back into the schist. To obtain this pulsating current of water Mr. Meynier obtains, by the action of a forcing pump, which draws the water from a lower reservoir and forces it into a cistern where

FIG. 6.



MEYNIER'S MACHINE

it acts upon the coal through a sieve or perforated plate. The first machine made, in 1852, consisted of a vertical pumping cylinder giving 15 to 18 strokes per min. The washing cistern contained 2 compartments and 2 grates; the denser bodies fell through the upper grate upon the lower one, which was more inclined, and they collected at its foot, where they were emptied at intervals into one of the compartments. This disposition of superposed grates was found to be unnecessary; several other modifications were also made in the disposition of the parts, so that Mr. Meynier's machine, in its simplified and improved form, may be described as follows:

A horizontal pump of 3 to 4 horse-power, with close fitting piston. The water is conducted through a horizontal cast-iron pipe, provided with a valve to regulate the flow, and ending in a long rectangular opening in the bottom of the washing cistern. This form of opening tends to spread out the ascending current

of water. This action is assisted by an oblong plate or valve which can be raised or lowered upon the opening. The flow of water is thus spread out in one of the compartments of a rectangular cast-iron cistern; at the top of this compartment is a perforated sheet of zinc, slightly inclined from the horizontal, upon which is charged the slack coal either direct from the mine or after passing through crushing rollers. A floodgate along the dividing line of the cistern, allows the schists, pyrites, etc., which accumulate along the lower edge of the perforated sheet to be discharged into the second compartment. Over this grate, and over the second compartment, the surface water, charged with washed coal, flows upon an inclined wire grating, where the water drips from the coal into a canal, whilst the coal gradually slides upon a horizontal wickerwork table, at the level of the top of the cars, from which it is loaded into them. There are no buckets and chains to elevate the coal in this machine, but they can be readily adopted if deemed necessary. The use of a bucket elevator would regulate the charging of the coal into the washing cistern, besides economizing labor. The water which finally drips from the coal contains a mixture of mud and very fine coal (called *schlamm* or slime), and is carried to a basin measuring 6.5 by 13 ft., and divided into successive falls.

The operation of coal washing is continuous, as the impurities which accumulate on the perforated sheet of zinc can be carried off at intervals by raising the floodgate without stopping the operation. The schists and pyrites which accumulate at the bottom of both compartments of the washing cistern, are extracted through side doors every day and carried to the refuse heap. The slime or schlamms which are deposited in the large basin are of very different value, according to their purity, which varies with the nature of the coal. When dried they may be sold for domestic use, or used to generate steam. They may be so highly charged with pyrite or schist as to be valueless.

This machine washes 50 tons of coal in 12 hours. According to Mr. Lebleu, the cost of washing with one machine is 7 cents per ton. When two machines are used, washing 100 tons daily, the first cost of each is $2,400, and the cost of washing 100 tons is as follows, in France:

1 machinist at 50 cents per day,..	$0 50
2 laborers... 50 " "	1 00
3 helpers.... 40 " "	1 20
Repairs of pump $120, of washer $120, ...	0 80
Superintendence ($200 per annum)	0 66
Sinking fund ($200 per annum)...	0 66
Total, for 100 tons,..........	$4 82

or 5 cents per ton.

RACTMADOUX'S MACHINE

Belongs to the third class. Mr. Ractmadoux obtains the continuous pulsating movement of the water by employing a piston, as in the jigging process, and introducing a supply of water at every upward stroke of the piston, by means of a valve opened. All the water which enters during that time is expelled at the next downward stroke, carrying with it the cleansed coal.

Mr. Ractmadoux also constructs all the parts of the machine of wood with iron straps. This allows defective pieces to be readily removed, and alterations suggested by experience to be easily made. At Montceau-les-Mines, Mr. Audemar has erected a washing apparatus on these principles. At these mines the coal is first sorted into three sizes by passing through shaking tables of perforated sheet iron; the sizes of the holes being respectively $\frac{4}{5}$, [illegible], $\frac{1}{8}$ of an in.; the surfaces of the tables measure 67 by 32 in. The amount of coal sorted per 10 hours is 150 tons; the Montceau coal gives 20 to 25 per cent. of finest, 30 to 32 per cent. of medium, and 18 to 20 per cent. of coarser slack.

Each of these three sizes is washed in a separate machine; this facilitates greatly the separation of impurities.

The apparatus consists of a water reservoir, two chests divided into three compartments, for the piston, the schists, and the "schlamms." These impurities are withdrawn once or twice a day while the machine is at rest. The coal and water current flows over one edge of the chests on an inclined plane, 6 ft. long, into two additional washing chests, provided each with a piston and inclined sieve. The coal is there cleansed further, and separates itself into a superior quality which flows off the top, and an inferior, taken at the bottom of the layer.

The pistons and chests are of wood.

The pistons are commanded by a belt-gearing and iron connecting rod; at each upstroke of the pistons a valve in the reservoir is opened by a lever and beam, and the water flows from the reservoir under the pistons.

Three of these double pairs of chests are placed side by side, each pair, with accessories, occupying an area of 20 by 14 ft. The area of pistons is 50 by 15 in., the area of sieves is 30 by 50 in.

In 12 hours the amount washed is 300 tons of slack coal, 150 of which are coarse, 90 medium, and 60 fine grain.

The loss from schist averages $4\frac{1}{2}$ per cent., from schlamms, $2\frac{1}{2}$ per cent., from slime carried off by the water, 3 per cent.; together 10 per cent. The consumption of water amounts to 180 cubic ft. per ton of coal.

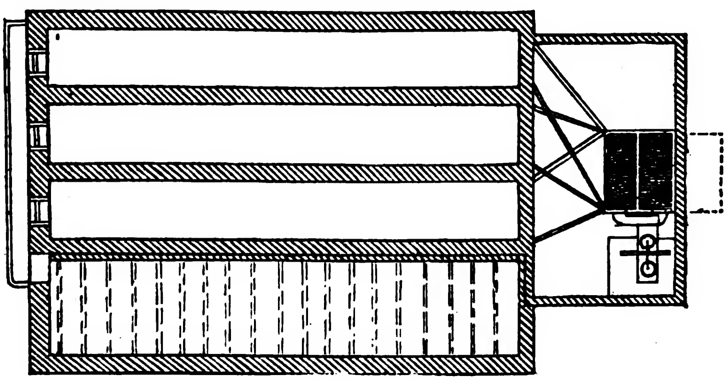
COPPEE'S MACHINE.

This machine, which is essentially derived from Meynier's, belongs also to the third class. It is working at the colliery of Anzin, at La Villette Gas Works, Paris, and at the Mons Colliery, Belgium, with one difference, however—the pump there used is double-acting.

Coppée makes use of two rectangular cisterns instead of one, so that the washing operation is more thorough to begin with. The purification of slaty coal is greatly facilitated thereby, for shale sometimes adheres to the coal, forming particles of intermediate density and light enough to be carried away with the coal; also some slates are formed of unctuous laminæ, which cannot be wetted, and are carried off at first, although heavier than the coal. A fall is given from the first cistern to the second, so that the dry schists are thoroughly wetted and submerged by the fall, and remain on the second perforated sheet.

From the second cistern the current of water and coal flows over a slightly inclined table into one of three basins.

FIG. 7.



COOPEE'S MACHINE.

These basins measure each 65 ft. long, 75 ft. wide, 7 to 7.5 ft. deep, presenting a cubic capacity of 3,530 ft., or one day's stock. They are built of masonry, and the bottom sloped to drain off the water. A vertical sluice at the further end is boarded up gradually as the deposit of washed coal rises in the basin; the excess of water and slime runs over the upper board into a canal to a fourth basin, the bottom of which is inclined against the current in a series of steps. The movement in this last basin is slow, and the black slime or schlamm deposited in this basin is dredged up, allowed to dry, and used for generating steam; at Anzin it is found to contain from 7 to 20 per cent. of ash. These basins assist in classifying the coal, for if kept full of water, the denser and more impure coals will accumulate at the bottom. These can either be washed again or used for purposes requiring less pure coal.

One of the three basins is filled every 24 hours; when full, the flow of water and coal is directed from the cisterns to another basin. The body of coal in the basin begins to dry at the surface, and the boards of the sluice are removed, one by one, from the top downwards, as the

drying progresses. The coal is then charged into cars, and the wet portions are first dried by mechanical means.

When the schists cover the perforated sheets to a considerable depth, the operation is stopped for a moment and the deposits of schist shovelled into a shoot which carries them to a car.

At Anzin the coal from the mine is thrown from the head of the shaft upon a grating, the bars of which are 0.8 in. apart. All the slack which passes through is charged into buckets containing 2,420 lbs.; these buckets are raised by a steam crane and discharged into a hopper placed near the washers. A vertical forcing pump, with hollow plunger, delivers the water to both washing cisterns. The diameter of piston is 26 in.; the piston is hollow, and the connecting rod is attached to a movable crank pin, so that the stroke which is usually 10 in. can be increased to 16. The number of revolutions is usually 20 to 30 per min. The steam cylinder is vertical, of 10 in. diameter and 19 in. stroke; the indicator diagrams for the forward and back stroke are nearly identical. At 20 revolutions per min. the average pressure of steam on the piston is 25 lbs. to the sq. in. corresponding to 4-horse-power.

The pump and washing cisterns are set up under cover in a building; the 4 basins are in the open air.

The labor for washing 100 tons of coal in 12 hrs. consists in 1 machinist who attends to pump and steam crane; 2 men hitch the buckets to the crane and discharge them; they also carry away the schists, etc., to the refuse heap; 3 men attend to the washing proper, and regulate the velocity of flow.

In France the machinery costs $2,400 gold, and the building, basins, and accessories, $5,000 to $6,000 more.

MACKWORTH'S MACHINE

Belongs to the third-class. Mr. Mackworth employs a continuous band elevator to raise the coal from a coal hopper, where it is delivered from the cars to a higher level, where it is discharged in a continuous stream into a vertical revolving hopper through which it descends gradually into the separator; here it meets a slow current of water ascending with a velocity of an inch or two in a second. According to the velocity of this current and the speed of the revolving hopper, the separation of impurities may be graduated to any limit desired.

The separator is a conical vessel 2.5 ft. wide at the top, at the bottom of which enters a current of water driven upward by a horizontal screw agitator. The slow ascending movement of water of about 5 ft. per min. carries upward the clean coal, and a curved arm at the surface drives it upward upon a perforated plate where the water drains off; a brush following the arm helps to keep the holes in the perforated plate open, and drives the coal into a shoot which conducts it to a tram. The bottom of this shoot is a long perforated plate which assists in draining off the water and in drying the coal.

The shale and pyrites fall into a shale box at the bottom of the apparatus, where a bucket elevator dredges them up and delivers them into cars. The water which drips through the finely perforated plates passes back to the agitator and, with the fine silt suspended in it, is driven up again. The same water is thus used over and over again, with some additional water to supply the waste.

The loss of coal in this machine is claimed to be less than 2 per cent. The machine is contained in an area of 9 ft. sq. A driving pulley 2 ft. in diameter making 40 revolutions per min., is placed at the top, 12 ft. above the ground. It is claimed that a force of 1-horse-power will work a machine with pump and elevator capable of washing 50 tons of coal per day. The cost is estimated at 6 cts. a ton in England.

DRYING THE COAL.

After washing, some industries require the coal to be dried before using, as in the production of coal-gas. Any warm area is suitable for the purpose.

Centrifugal hydro-extractors may be used here as in other industries. In Belgium, a centrifugal apparatus is used, consisting of a vertical drum 10 ft. in diameter, within which are 8 baskets fastened at the circumference of a horizontal plate. A velocity of 225 revolutions per minute is given. Each basket holds 88 lbs. Its centre of gravity describes a circle 7.5 ft. in diameter, and its axis becomes alternately horizontal and vertical. From 4 to 5 per cent. of water is left in the coal as a proper amount. Two men can load, dry,

and unload 30 tons of coal in 12 hours. This process is slow and expensive.

A new hydro-extractor, due to Mr. Hanrez, of Belgium, has been tried in Germany. The machine requires no hand labor. The operation is contintuous. The wet coal is carried into a feed hopper by a bucket elevator, is delivered into the centrifugal cylinder at the top, and discharged dry into a shoot at the bottom. This machine will dry 100 tons a day.

COMPARISON BETWEEN THE VARIOUS MACHINES.

The step-washing of coal is still used in coal districts possessing an abundant supply of water. The apparatus is simple and the first cost small. This method of cleansing is especially adapted to coal containing laminæ of slate frequently interstratified with it; in the ordinary jigging process, and in the third class of machines, these slates are difficult to eliminate, for they assume a flattened form, and on account of the greater surface they present to the action of water, they are carried upward with the fragments of coal, which are generally cubical in shape, and present less surface for a given weight.

The hand jigging machine, although very effective, requires too much labor to cleanse a small amount of coal.

Bérard's machine presents unnecessary complications. *Revollier's* second machine is an improvement upon it, besides separating the cleansed coal into two qualities. *Edwards and Beacher's* device to impart the jigging motion to the water is simple and ingenious; but whether the oscillations produced are sufficient, and whether the diaphragms are more convenient than pistons, I have been unable to ascertain. Of all the machines of the second class, however, *Evrard's* is the most perfect, for besides subjecting the coal to the jigging process at various depths under water, the rotary motion of the sieve subjects the coal to a lateral or horizontal current of water of 15 or 20 feet per minute, which aids the separation of slate. The first cost of this machine is large, but it cleanses more coal per day, and affords of itself a slime pit without any additional masonry work. Besides, the separation of cleansed coal into three qualities is more easily controlled than in other dispositions. The consumption of water is reduced to a minimum in this machine.

Whenever the jigging process is applied, however, the coal used should not contain much very fine coal, for the downward current of water at each stroke is prejudicial to the finer particles of the best coal. These are repeatedly carried back and mixed with the impurities, and even when deposit basins are used, although this fine coal is finally collected and not wasted, it is nevertheless taken from a superior and transferred to an inferior quality of coal.

The third and fourth classes of machines, where the water does not return upon itself at every stroke, are then particularly adapted to treat coals which produce a great deal of fine coal dust; for this fine and valuable dust is then never entirely separated from the clean coal, and they are mostly deposited and collected together. Coppée's machine is more complete, and an improvement upon Meynier's; it is effective in collecting waste of fine coal and in separating slate.

Ractmadoux's machine is similar to Coppée's, and may be often preferred where wood constructions present advantages. Mackworth's machine is very compact; it does not waste the fine coal, for the same water is constantly used over again; whether the slow continuous current of water of Mackworth's machine is as effective in separating impurities as a pulsatory motion, is doubtful. This machine is also inferior in respect to classifying the cleansed coal into superior and inferior qualities; this, however, is not always required.

There are some points common to all these machines; *i.e.*, the coal has to be delivered from the cars upon a sieve. The use of an elevator formed of an endless chain and buckets, discharging the coal into a hopper, is advantageous; for it allows the supply of coal to be delivered with great regularity, which is essential to the proper working of all these machines. Even where the lay of the ground affords sufficient difference of level to allow the cars to be discharged directly into the hopper which feeds the sieve, it is desirable to regulate by mechanical means the regularity of the supply of coal.

A location upon sloping ground, and a high head of water, are always advantageous; they may allow elevators and pumps to be dispensed with. The intermittent flow can then be obtained directly

from the head of water. An abundant supply of water is of course advantageous; nevertheless, some machines, such as Evrard's, purify coal effectively with a very small consumption of water.

Whether it is best to erect a single large machine or a number of smaller ones, is an open question. One large machine works more economically when in operation; but for convenience of repairs a number of small machines is more convenient, and also safer. The permanence of the operation should also influence the choice. The amount and nature of the impurities, as well as the friable nature and mode of fracture of the coal to be cleansed, are of first importance in the choice of a coal-washing machine. I have known a case where an excellent machine was erected at some cost, and when put in operation proved unsatisfactory. The nature of the coal had not been considered; the coal was slaty, and when crushed broke up in *flat* fragments, while the machine chosen was especially adapted to operate upon *cubical* fragments.

The cost of washing mentioned at different times is the cost in Europe in gold. This affords but little indication of what the cost would be in this country; some elements, however, remain unaltered, such as the labor required, and the production of the various machines.

PERFORATED IRON PLATES.

For trommels, perforated iron plates are now generally used instead of wire screens. They wear better and maintain their form longer. The finer sizes are made of copper and the larger ones of steel; sometimes sheets of zinc are used. The rules sanctioned by practice to be observed in preparing these sheets, are as follows:

1. The thickness of perforated iron plates should always be less than the diameter of the holes punched in them.

2. The space between the holes in the finer plates should not be greater than the diameter of the holes, in the medium plates than half the diameter, and in the coarser plates than one third of the diameter.

When the diameter of the holes is less than $\frac{1}{10}$ of an inch, the size is considered fine; when the diameter is between $\frac{1}{10}$ and $\frac{1}{5}$ of an inch, the size is medium.

COAL-WASHING IN EUROPE.

Machines have been established in Scotland, Cumberland, Derbyshire, Gloucestershire, and Wales, to purify from 20 to 100 tons of coal per day, at a cost not exceeding 6 cents per ton and with a loss not exceeding 2 per cent. of coal.

At the Kirkless Hall Iron Works of the Wigan Coal and Iron Company all the coal dust for the coke required in the blast furnaces is purified from sulphur by washing, and is made suitable for *smelting a high class of hematite iron* for the Bessemer process; the cost does not exceed 4 cents per ton including wear and tear of machinery, steam power, and wages. The waste is about 10 per cent. of impurities and fine coal.

The most important coal district on the continent, is the Valley of the Saar at the frontier of France, Rhenish Prussia, and the Bavarian Rhine province. At the Burbach Iron Works, which are the largest and best arranged of that district, the coal is carefully washed previous to coking; the machinery for carrying out this operation is very complete and effective; the coal is impure and loses 12 per cent. by washing.

At the Kladno Iron Works, Prague, which are the largest in Austria, the fuel used is coke made on the spot from Bohemian coal. The coal of the Kladno mines is very impure and stratified with thin layers of slate, so that *it will not coke at all in its natural state;* it contains a considerable percentage of iron pyrites in crystals of very different sizes, which would render the coke worthless for iron smelting, unless made from picked or purified lots of coal. Yet from these impure coals and from ores containing sulphur and phosphorus, *very good foundry iron and an average quality of forge pigs* are made.

In the centre of France, the St. Etienne district, and in the Northern basin of Anzin, in France, and Mons, in Belgium, coal is washed by hundreds of thousands of tons annually.

The railroad from Kharhof to the Sea of Azof was completed on the 4th inst., thus effecting uninterrupted communication from the Baltic to the Black Sea. The construction of the line, which is upwards of 400 miles long, was only commenced last summer.

NEW GAS-STOVE AT THE ROYAL OBSERVATORY, EDINBURGH; AND THE MANUFACTURE OF WATER.

By C. PIAZZI SMYTH, F. R. S., F. R. A. S., Astronomer-Royal for Scotland, etc.

In a litte garret-room at the Royal Observatory, Edinburgh, there has been introduced a gas-stove, now for nearly a year, with remarkable success after certain principles were efficiently carried out. The proof of success is, 1st, that the temperature of the garret is now from 10 deg. to 15 deg. higher than a similar neighboring garret without a stove. 2d. There is a hot closet, where articles may be maintained night and day at a temperature of about 100 deg. 3d. There is no bad air from the stove, and the garret is indeed sweeter than it used to be before the stove was erected, because the means for conveying away the bad or burned air of the stove are made to remove the bad air from illumination or respiration of any occupants of the garret. 4th. There is no trouble either by day or by night, for the stove is kept constantly burning, and simply produces an accession of heat and comfort to the garret, as if the stove was a natural hot-spring, or "that it went like a clock." 5th. The expense is exceedingly small, on account of the trifling quantity of gas burned; though, that gas being also economically burned to a degree, there was a trouble at first connected with the fountain of water; of which more presently.

METHODS.

1. The supply of gas must be constant; there is, therefore, a regulator of pressure, through which the gas passes before entering the stove, and this completely prevents the flaring up and roaring of the gas-burners, which is experienced in ordinary gas-lights when the pressure is altered on the street gas-main, either by the Gas Company or by the shops turning on or off.

2. The gas is burned in ordinary small "fish-tailed," or "Union," burners, of which there are three, of the smallest size manufactured; and, according to the season, either one, or two, or three are lit. They are preferred to the Bunsen burners, from the cheerful light that they throw out at night through glazed doors in front of the stove; also from burning the gas at least as perfectly, if not more so, from the higher temperature of the bright flame; and also from not being subject to occasional back ignitions, and then smoking, as are the Bunsen burners.

3. The stove is made of sheet iron; it is 32 in. high, 25 in. long, and 18 in. broad at the bottom, but only 4 in. broad at top,—this decrease being produced by the front slanting backwards, as shown in Fig. 1.

5. The heated products of combustion are not allowed to escape upwards to the top of the stove at once, but are made to pass backwards and forwards under 4 successive horizontal diaphragms, before arriving at the chimney, at the upper right hand corner. These diaphragms are fixed in their places by rivets which project outwards an inch. These serve to communicate the heat of the diaphragms to the outside air, as well as to hang things on to be heated or dried; and what with sides and diaphragms of the stove, the heated products of combustion of the gas-lights have to pass over 25 sq. ft. of metal surface before escaping to the chimney. This is an excessively large amount of surface in proportion to the quantity of gas burned, and hence, in a large measure, the economy of the stove.

6. The hot closet is formed by a box or wooden head put over the upper half of the stove, and furnished with drawers and a closet door, as shown in Fig. 2.

The top of the closet and the door are both of plate glass, so that the face of watches, if put inside to be tested for going at high temperatures, may be read as they lie there at these temperatures.

7. To carry away the gaseous products of combustion, there is a chimney formed of a metal pipe 1.5 in. in diameter, which passes through a hole in the ceiling of the garret to the open air outside the roof; the hole being so much larger than the chimney pipe that its annular difference makes a chimney for the bad air of the garret as well.

8. In calm weather, the stove chimney and garret ceiling chimney both act well by the ascensional power of warm air; but in times of wind, the currents are more inclined to blow down than up—the situa-

tion being very exposed, and the winds violent to a degree.

9. To correct these downward currents, therefore, in times of wind (simple cowls having been found inefficacious), there has been established over the top of the two united chimneys a little vertical windmill, working a modification between an Archimedean screw and a fan-wheel, the conical blades of which are always drawing the bad air out of both chimneys, and expelling it to leeward. The action of this apparatus is most admirable, most necessary; for whereas the burning of a single *un*ventilated gas-light in so small a garret makes the air noxious in a quarter of an hour, the ventilated gas-burners keep on burning both by day and by night, and week after week, without any smell or other bad feature being perceptible.

CHIMNEYS IN THEORY AND PRACTICE.

10. A word more on the chimney arrangements of the gas-stove, as applicable to any and all chimneys.

The usual circumstances under which chimneys smoke, or have back draughts, are,—at the chimney-top, where the products of combustion ought to escape, the winds are howling, like ten tigers, and doing

FIG. 1.

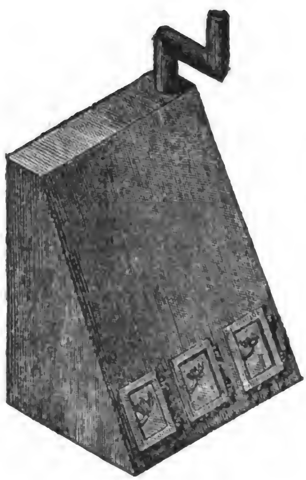
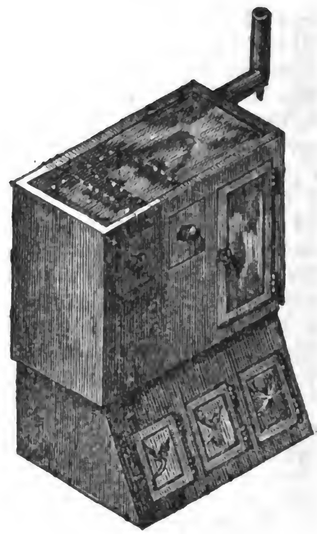


FIG. 2.



their utmost to get down the chimney, and so enter the fire-place room, where the fire, by burning and making some upward movement of the air in lulls between gusts of the tempest above, produces a rarefaction.

Architects generally seem to fancy that a principle merely is quite enough for actual practice anywhere; and, therefore, trusting that there is an ascensional tendency in hot air from a fire, though ever so small, inducing it to go up a chimney, they leave that often very weak, almost homœopathic force to contend single-handed against two difficulties—*first*, to wire-draw some air of supply through closed doors and windows; and *second*, to eject the burned air right in the face of the struggling winds and whirlwinds at the top of the chimney-pots. A very little calculation would show that the result must be practical failure, *i. e.*, a smoky chimney, although the ascensional principle of warm air be perfectly true.

No person who lives in a very windy and trying locality can expect to be free from smoky chimneys, unless he corrects both of the evils above mentioned. Let him also, by all means, have as tall a chimney as he can; let him see that the top of it is not dominated by any neighboring mass higher than itself; and let him keep the chimney-stack as warm inside as he can, to promote the ascensional power of warm air; but let him also supply these two things: 1. A pipe to bring fresh air to be burned from the outside, top, and most windy part of the roof; and 2. A *power*-cowl to extract the burned air, and throw it out into the atmosphere,

despite any number of winds howling to get in.

With the Observatory stove, there is an inch-pipe to bring fresh air to be burned in it, not exactly from the outside of the roof, but from a very windy region between the roof and ceiling, which does almost as well. And then for the ejecting of the burned air, there is a little vertical windmill working a diagonal screw fanner as aforesaid.

To those who want a tolerably large measure of efficiency and no trouble in such a *power*-cowl, I would say, get one of James Heworth's patent Archimedean screw ventilators; but to those who have a fancy for realizing the utmost power of the wind according to Smeaton's laws for vertical windmill sails, and do not object to experimenting, I am inclined to say, try the Edinburgh Observatory plan of a vertical sail-wheel kept at right angles to the wind's direction by being at the *leeward* end of the wheel's horizontal axis (instead of the *windward* end, as with ordinary windmills, when they need a special and expensive apparatus to turn their faces always to the wind).

The collar-motion, by which the wheel's face is turned towards the wind, must be rather stiff than free or light; but the motion of the axle of the sail-wheel round itself must be as free and light as possible; and to promote its always turning even in very light airs, the sails, which are plates of tin, are fastened at the most suitable angle for *beginning* to turn, and are fastened by their front edges only; hence, when the wind blows strong, and the wheel is inclined to turn needlessly fast, the tail-ends of the sails are blown or bend more nearly in the direction of the axis of the wheel, and thus slow their motions and decrease the surface on which the wind can act.

MANUFACTURE OF WATER.

11. Let us now suppose that everything has been well-managed thus far with one gas-stove, viz.:

A. Its supply of gas is constant; B. the lights never go out; C. the supply of fresh air to it is always ample, whether doors and windows be open or shut; and D. the extraction of the burned air by the chimney and *power*-cowl is also perfect, no bad smell being ever perceived. Still there is one thing to trouble our comfort—"water, water everywhere," and truly "not a drop to drink." Water issues out of every crack or pore of the chimney, perhaps of the stove also, and it is slobbered about on the roof above out of the cowl's top or out of the sides thereof. Where does all this water come from?

It is the product of combustion; the combination of the hydrogen of the gas with the oxygen of the air; and this is indeed a means of manufacturing water in any place where we can get fuel and air. The Royal Observatory, Edinburgh, on the top of the Calton Hill, is unfortunately far above the level of the water-column of Edinburgh; but its gas-stove up in its topmost perch, just under the roof, is manufacturing water both by night and by day; and enough of that manufactured water is collected now to form a very useful tank of supply—the only supply, if ever the misfortune of a fire should occur.

But why does not water appear similarly, some one may ask, at every fire-place; and why cannot our Southern travellers, dying for thirst in the wilderness, manufacture a supply of water for themselves by merely setting the grass on fire? Merely this one difficulty—the fuel in these cases is not burned *economically*, or according to economy in warming, *i.e.*, the heat is not sufficiently taken out of the burned gases; hence all the water these gases are carrying away is in a state of vapor very highly vaporized, and it refuses to deposit upon anything. But when, as already described in the Observatory gas-stove, the burned air from merely a single gas-burner is made to travel over 25 ft. of conducting metal in the stove, its temperature has been so much lowered that the vapor of water hitherto held in suspension deposits almost immediately it enters the chimney, that chimney being in this case a metal tube, almost like the worm of a still reversed. At first it was a soldered tube made of zinc plate, but that leaked so determinedly, and disastrously too, at all sorts of places, that it had to be substituted by a stout leaden pipe; and this again, to prevent the chimney water running back into the stove, had to be made with a bend-down, before entering, or rather after leaving, the stove, as may be seen in Figs. 1 and 2, that bend being further provided with a stop-cock or place of escape for the water that runs down to it.

At that point there is now a glass jar always placed to catch the water as it falls out; and an exquisite sight it is when full, the water being colorless, clear to admiration, and refractive nearly as crystal —this latter quality arising from the salts held in solution, and which are probably enough, after all, to prevent drinking water being ever manufactured in this way, so long at least as it can be procured in any other, and men are not absolutely dying of thirst.

As to the quantity of water that is produced in this manner, I can only speak as to what forms in the *vertical* part of the chimney-pipe, for a long horizontal portion of the same beyond ejects its formation upon the open roof, and, evaporating there, makes a white, chalky-looking mess. But in the grass plot, under the vertical portion, there are caught in 24 hours, when all 3 burners are alight (consuming apparently a little under 120 cubic ft. of gas in that time) 50.6 cubic in. of water.

DETERMINATION OF THE SATURATION POINT OF STEAM.

By G. A. HIRN.

Translated from "Der Civil Ingenieur."

It is a fundamental law of thermodynamics, that the quantity of heat given off by a body during its return to its original condition, is equal to the mechanical work which it has developed. If this work is zero, the amount of heat remains constant.

Suppose that steam of tension P_0, and density V_0 is generated in a boiler, and that it passes without change of tension through a vessel in which its temperature changes from T_0 to P_1, and its density from V_0 to V_1. As it enters a vessel containing gas of tension P_1, it expands suddenly, and its density and temperature are converted into V_2 and T_2. As the wall of this vessel is of the temperature $T_3 \angle T_2 \angle T_1 \angle T_0$ it is condensed and returns to its original condition. These processes are complicated, but the final calorimetric result is simple. The heat expends on the water in the boiler an external work equal to P_0 V_0, and an internal work L_0, which separates the molecules. In the superheating apparatus there is exerted an external work P_0 $(V_1 - V_0)$ and an internal work L_1; both corresponding to a quantity of heat Q. If the steam enters a condenser, the molecules acquire a very great velocity (about 800 metres), which is lost in eddies, shock, and friction; and the consequence of the condensation of the steam under the pressure P_1 is external work, P_1 $(V_1 - W_0)$, and internal work, L_2, corresponding to the compression of the molecules.

All this work in boiler, superheater and condenser, expresses itself in the bubbling noise of the boiling water, and the hissing of the issuing steam; and its dynamic value may be neglected. It is partly negative, partly positive, and the resultant is zero.

In whatever way saturated or superheated steam is condensed, whether by sudden expansion from P_0 to P_1 (say 5 atmos. to 1 atmos.), or by injection of cold water; the quantity of heat must be at least the same as at first.

If t_0 is the temperature of the steam,
M the weight of a given volume,
m the weight of the injected water,
then in order to produce a mixture of water and steam from water of the original temperature 0°, under a pressure P_0 corresponding to a temperature t_0, there must be employed a quantity of heat

$$Q = M(606.5 + 0.305t_0) + m\,C\,t_0;$$

C being the specific heat of the water. According to Regnault

$$m\,C\,t_0 = m\,(t_0 + 0.00002\,t_0^2 + 0.000000\,t_0^3)$$

This quantity Q must be found again in the condensation, if the steam has no external work to do; a condition easy to realize, if the steam issues directly into cold water, thus preventing the rushing noise which indicates the performance of external work.

Let N = the weight of the cold water,
t_0 = the final temperature,
t_1 = the initial temperature;
then m can be determined from the equation—

$$M\,(606.5 + 0.305\,t_0 - t_2) + m\,C\,t_0 = N\,C^1\,(t_2 - t_1)$$

The exactness of the value of m depends on the exactness—

1. Of observations of the temperature t_0, t_1, t_2.
2. Of the weight N (especially of $N + m + M$).
3. On the prevention of loss or gain of heat.

The mercury-gauge gives the pressure P_0 exactly, and t_0 can be found from Regnault's tables; t_1, and t_2 can be observed to within $\frac{1}{400}$ by means of a thermometer divided decimally read with a microscope. If $t_2 - t_1$ is not greater than 20 deg., the temperature of N can be determined to within $\frac{1}{800}$. If with reference to the external temperature t,

$$t - t_1 = t_2 - t,$$

and N is very large, the errors resulting from the external cooling or heating of the condenser are practically eliminated. By means of Kappelin's hydrostatic press $N + M + m$ can be weighed to within 0.0001 kil., for a gross weight of 30 kil.; giving a sufficiently accurate value of $M + m$. The rushing of the steam due to the condensation and the consequent loss of work can be prevented in a great measure by conducting the steam into the cylinder by means of a long bent tube with a narrow opening. The steam is partly condensed in the tube under the pressure P_0; so much so that hardly any sound is heard during its passage.

Another method is of more limited application, but leads to more accurate results; it is more limited, since it is suited only to the generators of steam-engines; more accurate, because it specifies the amount of water of condensation used during an entire day.

Suppose the whole quantity of water and steam which the boiler of a condensing steam-engine gives off to be determined; and that

W = the quantity,

m = the unknown quantity of spray water,

t_0 = the mean temperature of the mixture,

t_1 = the mean temperature of the water of condensation; then the quantity of heat expended by the boiler is given by the formula

$$Q_0 = (W - m)(606.5 + 0.305\, t_0 - t_1) + m\, c_1\, (t_0 - t_1).$$

Again if

N = the weight of the condensing water,

t_2 = the temperature of the water injected, the quantity of heat which this water takes up is

$$Q_1 = (N - W)\,(t_1 - t_2)\, C.$$

But in this case Q_1 is not equal to Q_0, if the external work is not considered.

If F is the effective work of the steam, as shown by Watt's indicator, we have, from a fundamental principle of the theory of heat,

$$425\,(Q_0 - Q_1) = F$$

and hence

$$(W - m)\,(606.5 + 0.305\, t_0 - t_1) + m\, c_1\, (t_0 - t_1 = (N - W)\,(t_1 - t_2)\, C + \frac{F}{425},$$

which gives

$$M = \frac{(N - W)(t_1 - t_2)C + F \div 425 - W(606.5 + 0.305 t_0 - t_1)}{C_1(t_0 - t_1) - (606.5 + 0.305\, t_0 - t_1)}$$

As t_1 seldom amounts to 40 deg., we can, without great error, put $C = 1$. According to Regnault's formula

$$q = \int_{t_0}^{t_1} C^1 d\, t = t_0 + 0.0000\, t_0{}^2 + 0.000000.3\, t_0{}^3$$

and with close approximation

$$C^1\,(t_0 - t_1) = t_0 - t_1 + 0.00002\, t_0{}^2 + 0.0000003\, t_0{}^3.$$

The exactness of the value of M so calculated, depends on the accuracy of the values of W, N, and F.

This method serves to test an engine, by determining its efficiency, and detecting its faults. Suppose 5 of the qualities W, m, N, N − W, and F, to be known; then the sixth can be determined. We cannot too strongly recommend to engineers that they make experiments in this direction wherever opportunity occurs.

In England a patent apparatus is used, which is applied to the orifice of the condenser, and registers the volume and temperature of the water discharged; that is, it continually records values of N and t_1 coarsely approximate.

With reference to the determination of the weight of water and steam, W, furnished by a boiler in a given time, but little can be said. At present we have no direct means of determining the quantity with accuracy; still the measurement of the amount of supply is a simple and easy method of obtaining the desired result. Several kinds of registering apparatus have been invented, no one of which is certain in its indications.

Still more difficult is the exact determination of the amount of water, N, discharged from the condenser. In large engines

this amounts to 6, 7, and 8 kilos. in a second, or 4 to 5 cubic metres in 10 minutes. It is not easy to gauge with accuracy such quantities. The best method is by division into small quantities and summation. The water lifted by the condenser is discharged into a long box 1 @ 1.2 m. high, 0.4 @ 0.5 m. broad, and 1 @ 1.2 m. long. In the bottom of this box is fixed a long strip of brass or lead, pierced with round holes as nearly equal in area as possible, having a diameter of 15 @ 20 millim. The orifices should be from 15 to 20 millim. apart. The discharge from an orifice of 20 millim. diameter under a head of one metre is 0.8 kilog. per second. So that six or seven are necessary to discharge 5 @ 5.5 kilog. in a second. The discharge of each orifice should be measured by the water-inch. This is accomplished by stopping the orifices with corks, filling the reservoir with water of a temperature equal to that of the water of condensation, and then uncorking the orifice whose discharge is to be determined, and counting the number of seconds required for the surface to sink from 0.4 to 0.5 metre. If

S = the transverse section of the vessel.

H_0 = height of water at first observation.

H_0 = height of water at final observation.

T = interval of time.

Then

$$\frac{2s}{T\sqrt{2g}}(\sqrt{H_0}-\sqrt{H_1})=(\mu S)$$

and the quantity ef discharge under the constant head of H is

$$V=\mu S\sqrt{2gH}.$$

The area of the transverse section of the vessel is most accurately determined by weighing the quantity of water required to raise the surface from H_0 to H_1. The total discharge is of course the sum of all the partial discharges determined by the process described. Suppose that the sectional area of the vessel is $1.2 \times 0.5 =$ 0.6 sq. met., and the surface of the water falls from 1.2 to 0.8 met.; then

$$T\mu S=\frac{2\times 0.6}{\sqrt{19.6176}}(\sqrt{1.2}-\sqrt{0.8})=0.05446195-T.$$

For the openings of 2 centim. diameter we have approximately

$$\mu S=0.6\times 00031416=0.000188496;$$

hence

$$T=\frac{0.05446195}{0.000188496}=288.9 \text{ seconds.}$$

The time can be observed to within ½ a second, so that the value of μ S can be obtained to within $\frac{1}{380}$. The height H_0-H_1, when about 0.4 metre, can be found within ½ millim., or within $\frac{1}{800}$. Consequently the value of N can be found with great accuracy from the equation

$$\frac{1}{\gamma}N=\mu S\sqrt{2gH}$$

in which γ is the density of the water and H the mean head.

The quantity of water, N, discharged from the condenser into the measuring vessel is found by observing the head, H, for every minute during half an hour's time, and taking the means of the values given by the formula

$$N=\gamma\mu S\sqrt{2gH}.$$

The accuracy of the value thus obtained depends upon the exactness of μ S, and thus in turn upon the exactness of the measurement of the section S.

The quantity, m, is found by comparison of N with the quantity W found by direct measurement. Let us suppose $\mu = 0$, which happens (1) when work is done by superheated steam, or (2) when the cylinder is well packed.

In the first case

$$W=\frac{N(t_1-t_2)+F\div 425-}{606.5+0.305\,t_0+0.48(T+t_0)-t_1+C(t_1-t_2)}$$

in which T is the temperature of the superheated steam.

Very complex relations occur in the case of cylinders with steam jackets, to which we will briefly refer. A portion of the steam condenses in the jacket, on account of the external cooling; another portion condenses because of the loss of heat by the expansion and cooling of the steam in the cylinder.

The advantage of Watt's steam jacket consists in this interchange of heat and effects a saving of 20 per cent., according to my own experiments as well as those of Combes.

Again, a portion or all of the spray-water is precipitated into the steam jacket. I have assumed that all the water is precipitated; but, as remarked by M. Leloutre, it does not matter whether all or but a part reaches the cylinder, for this

water would be converted into steam by the heat imparted to the cylinder, and a volume of steam corresponding to the spray-water would be condensed in the jacket. In all well-constructed engines the cylinder is placed over the water surface of the boilers, so that the condensed water can run back, or, where this is not practicable, the water is allowed to escape from the jacket.

In these cases $\mu = 0$, and we have

$$W = \frac{N(t_1 - t_2)C + F \div 425}{606.5 + 0.305\, t_0 - t_0 + C(t_1\, t_2)}.$$

Hence, if N, t_1, t_2, T and F, are known (by the indicator), the steam required at any moment can be determined; hence the advantage of this method. For example, if W is determined from the amount of supply, one must observe at least 12 hours to obtain a trustworthy result; but with this method it is only necessary that the engine work 30 minutes in order to determine the amount of steam consumed, so that many trials can be made in one day, under varying relations of tension and expansion.

The total work of the steam in the cylinder can be found within $\frac{1}{500}$th by Richards indicator; or it can be calculated from the equation above after measurement of W. The quantity of heat $\frac{F}{425}$, and consequently F, is obtained from the difference, $Q_1 - Q$, of two large numbers which depend upon very many elements difficult to determine. Small errors which enter into the experimental factors of Q and Q_1, introduce great errors in the value of F. In my earlier experiments to determine the mechanical equivalent of heat, I employed this method, and the results have been proven incorrect.

Finally, we now have in industrial physics two exact methods for measuring the quantity of spray-water from the boiler, and one of these methods, besides giving the special results referred to on this article, is sufficient for the most complete investigation of the steam-engine.

IRON SHIPS AND IRON-SHIPBUILDING.

From "Appleton's Journal."

There is now living in England, at a not extreme old age, a ship-builder, who declared that the building of ships with iron was against Nature, and that he, for one, never would use that material. Whether he has used it, we are not informed; still, he has lived to see the use of wood as rare in that country in that business, as was iron when he made that assertion. Like all new inventions which are radical improvements, the use of iron for ships' bottoms met with much opposition, was slow to come into use, and the details of its manufacture imperfect. Still, when we look at the fact that it was introduced in England; of the immense prejudices to be overcome; that it had, in a measure, to be forced upon an Admiralty and Board of Underwriters, and a people wedded to old ideas; that its use came in direct opposition to, and threw out of employment, a wealthy class of builders of wooden ships and their numerous workmen, and made necessary a new knowledge of construction in naval architecture, thus having arrayed against it all the prejudices of ignorance and interest, we cannot but wonder that the introduction has been so rapid. We may almost say that, viewing all these things, the progress of the use of iron for the building of ships has been without a parallel in the history of inventions.

We can well imagine the incredulous sneers with which the old style shipwrights spoke of the possibility of making iron float, and what faint hopes the friends of the seamen who first took voyage in an iron ship had of ever seeing them again. And still, with what exultation the same shipbuilders hailed the news that one iron ship had parted her seams in a gale and foundered at sea, and another, beached on the shore, had "hogged" and broken amidships! But the shrewd moneyed men soon found that the iron ships brought more cargo, and their average loss by shipwreck or otherwise was not even so great as the wooden vessels, while on the score of economy in construction they had greatly the advantage. Science, as it progressed, has made them still more safe by the introduction of bulkheads—at least an apparently new idea, certainly one never thought of in England, though familiar

enough to that strange people who are behind us, yet ahead of us, who know so much and yet so little—the Chinese—who had, perhaps, for untold ages, used a similar construction in their vessels; they being divided into many compartments, all water-tight, wherein was stowed each trader's cargo separate. The introduction of the bulkhead system of construction marks an era in iron ship-building, and a vast step toward the perfection of safety in travelling by water. Numerous instances are quoted of vessels sailing hundreds of miles with one compartment filled with water, some with two, and we have ourself seen an English steamer land her passengers and two-thirds of her cargo in New York perfectly safe and dry, when she had a hole in her bow through which one might have easily driven a horse and cart.

The great difficulty in the early history of iron ship-building was to get a rating at Lloyds'. That conservative establishment, acting upon the motto, "Prove all things; hold fast to that which is good," and, we might add, not be very anxious to take hold of any thing better, waited with great patience, and still with greater incredulity, the result of the experiment of the first iron vessels. Even when their good qualities were proved, they gave way reluctantly, and their rating is yet more on matter than manner, quantity than quality. Defective, however, as it may be, we must make allowance for the fossilized ideas of some of our English brethren, especially when we reflect how that sleepy old Board must have been taken aback by the innovation.

Lloyds' register has existed about one hundred and ten years, having been commenced in 1760. It was a crude affair at first, but about 1810 became a permanent and recognized institution, with a fixed set of rules for rating and building. It is natural that they should have some pride of antiquity about them, and equally natural that some prejudices as to shapes and materials of vessels should enter into their regulations. It has now on its register over 13,000 vessels, representing over 6,000,000 tons carrying capacity, and valued at over $700,000,000 gold. It pays out in salaries over $100,000 gold annually, and endeavors to employ the best talent for its uses. Their rating for iron vessels is, in brief: The iron must be capable of standing 20 tons' longitudinal strain per sq. in. For vessels of 2,000 tons and over, the iron must range from 11-16 to 15-16 in.; for 1,000 to 2,000, from 9-16 to 13-16 in.; from 500 to 1,000, 7-16 to 11-16 in. in thickness. Then there are specifications as to shape, rake, etc., position of iron of different thickness, interesting to no one but the practical ship-builder. Their highest rating is for 12 years.

This establishment has slowly been made to acknowledge that 10-16 of an inch of iron is as strong as 6 in. of their boasted oak, even when the iron was dug from and manufactured on their own soil, and they must have as long a time to learn that an American iron of 8-16 is at least of equal strength, and entitled to the same rating as the English 9-16ths. This question of allowing a different thickness on account of greater strength, is of immense importance to Americans, as ships built of our iron, equally as strong or stronger than the English, might be made of plates at least 1-16 less in thickness; hence would be that much lighter, and carry equivalently as much more cargo. But the influence of the English Lloyds extends over the whole world; thus even our own insurance companies follow their behests, and any ship-owner who dares transgress their rules would find his ship rated down here as well as abroad, and his insurance rates raised, notwithstanding he might build her of iron standing a strain of 75,000 lbs. to the sq. in. This state of affairs is not so especially applicable to vessels in our coasting trade.

The first iron vessels of which we have any definite record, were employed as canal boats in 1812, though it has been asserted that a boat, constructed of iron, was used on the Severn in 1789. In 1822 a vessel was built of iron, and run from London to Brest, navigated by Admiral Napier. In 1830, iron ships were introduced on nearly all the English canals, with paddle-wheels recessed in the stern; but the first to take a long sea-voyage was built at Liverpool, by Jackson & Gordon, for Cairns & Co., and launched October 17, 1838. She was named "The Ironsides," and measured 271 tons burden. She sailed to Rio de Janeiro and returned safely, with cargo dry. This experiment was soon followed by others. Until 1844, the only rating given them by Lloyds was,

"built of iron;" from that date to 1854 they were rated "A 1 for six years, built of iron;" in that year rules were adopted, which exist, as then, with some few alterations. We have above stated the principal points of these rules.

Among the first and most persevering builders of iron ships was Fairbairn; and his successors, the Lairds, still continue the business. He states that he built one hundred iron vessels, most of them at a loss, and saw them all successfully sailing on the ocean, before the Lloyds and Admiralty were willing to admit the success of iron as a material for shipbuilding.

The first ships were built by bringing both edges of the iron flush to each other, strengthened by a narrow plate inside the seam. This was soon abandoned for a system of lapping one edge of the plate over the next under, as in ordinary weather-boarding or slate-roofing. This is used by some yet, but has been almost entirely superseded for a system of alternate lapping, every other plate resting over, the edges of its neighbor. Some have gone back to the original idea, because of the smooth bottom it makes; but it is the almost unanimous opinion of ship-builders that strength is thus sacrificed to beauty and increased cost. Framing is used as in wooden ships—some using transverse and some longitudinal framing, most a combination of both. The ribs rise in one solid piece, from keel to deck-sides, are usually inverted ⊥ shape, or square ⊏ placed sideways, or thus ⊏, sometimes an L. These shapes are preferred.

The theory of iron ship-building is in brief this: A stick of timber, of a given size and length, weighing just a ton, will displace so much water and float; make a water-tight box of iron, the same size of the timber, so constructed as to also weigh just a ton, and it will also float, and displace the same quantity of water. Hence, it will carry just as much weight as the timber; then make your box the same size, but weighing only half a ton, and you find that it will sustain the other half ton weight in cargo. Therefore, as iron is ten times stronger than oak, or other ship-timber, it may be made ten times thinner, relatively lighter, and more buoyant. This simple experiment is the basis of iron ship-building, and, in itself, overcomes all the ignorance and the prejudice against the use of that metal. The only question was to determine shapes, and machines to work into the requisite shapes.

Mr. Scott Russell says, to make a good iron ship-builder, a man should be a good mathematician, a mechanic, and at least a theoretical naval architect; next, he should be a mechanical engineer, thoroughly understanding the different grades, qualities, and characteristics of iron, and also should have gone through with and understand practically every detail of the business. As a large part of the work in iron ship-building belongs to the machinist's and blacksmith's trade, the construction of such vessels was taken up by the same persons who built the machinery for steamers—the engine and machine ship-owners; and such must be the case here for successful and economical work.

Steel has also been used in England as a material for boat-building; and, where extremely light draught is required, has very decided advantages over iron, though much more expensive. The Lloyds reduce the thickness one-quarter of an inch for vessels built of steel. Another style of boat, lately introduced, but not likely to become very general, is called the composite, being composed of iron framing and wood planking. The only advantage claimed for it is, that the bottom may be coppered, but even then that metal has been found to act on the iron ribs and bolts.

Tonnage is not what weight a ship can carry, but, by English law, is the space she has, counting 100 cubic feet to a ton. Builders' tonnage is to multiply the length and breadth, then this by one-half the breadth, and divide this product by 94. The cost of building iron vessels in England is from £18 to £30 per ton, with an additional cost for steamers of £45 to £55 per horse-power. The materials there are considered to be about three times the cost of the labor. Mr. Scott Russell thinks a vessel should have one ton of tonnage for every mile of the journey she is to perform. His very perfectly proportioned steamer, the Great Eastern, of 18,915 tons, might have gone down to futurity as a magnificent failure, but for the grand work in which she is now engaged. Mr. Russell thinks, too, that a ship should have as many as seven breadths in her length. There is no doubt but local causes, and the character of freight to be carried,

must influence these proportions. Where speed is a desideratum, as in a passenger steamer, a narrow, long, shallow steamer is undoubtedly best.

In France it is stated that the cost of building is about the same as in England. As to the profits, it is stated that one company on the Tyne cleared 30 per cent. on its capital, in 1867, and declared a dividend of 12½ per cent. On the Clyde, the business is increasing, as also the number of firms. That river is now the chief seat of iron ship-building, and we append a statement of the work done there:

	Vessels of all kinds.	Tonnage
In 1863	170	124,000
" 1864	220	184,000
" 1865	267	158,300
" 1866	247	129,989
" 1867	241	114.598
Orders, end of 1867	130	115,124

Of those in 1867, only 32 were wood and composite.

On the Mersey, in 1867, there were 44 iron vessels built, tonnage 40,564, and 10 on the stocks; also 35 large iron barges built and 4 small composite vessels. On the Tyne, in 1867, there were 81 iron vessels built; tonnage 31,075. We have no exact statement of later date but the broad one that there was no decrease during 1868, and that the trade is still brisk, as of late years.

In the United States, the first iron boat was, we believe, built at Boston, to run from that port to Portland. So far, but two sailing vessels of iron have been built: one in Boston, the other at Wilmington, Delaware. At the latter place, and Chester, Pennsylvania, have been built nearly all the iron boats of this country—most of them river steamboats and coasting steamers. The largest and only ocean steamers built were constructed at the Novelty Works, in New York city. The business is rapidly growing in this country, as the number of vessels on the stocks and contracted for at Wilmington and Chester will attest. It is probable that, in those places, iron vessels can be built cheaper than in New York or Boston; that the Delaware and the Alleghany may be to this country what the Mersey and the Clyde are to England. We say the Alleghany, because we think that in time the wooden hull of our Mississippi palaces will be supplanted by the lighter and stronger iron. In a close calculation of cost, the saving in transportation of coal and iron must tell; and, too, there is, no doubt, much greater ease in controlling labor there than in the immediate limits of a large city. As the ship-building trade has left London, and is gradually concentrating around the great coal and iron centres—the Tyne, the Mersey, and the Clyde—the last having an acknowledged advantage over the others—so we may assume that the future ship-building of this country will be carried on nearest to its great coal and iron centre.

As to quality, no better ships than those built at Wilmington and Chester have ever floated in English waters—but few as good; and, as respects models for economy of fuel and great carrying-room, none ever were built by any nation superior to those of a line which takes a weekly departure from an East river pier to a Southern port. During the war, monitors and ironclads were built at various places, but, as these boats were all heavy wooden frames, iron-plated a few feet only, they hardly belong to the legitimate class of iron-built vessels.

We are assured that iron vessels can be built on the Delaware for about 5 per cent. more than in England—that such is the contract price for a number now on the stocks; while, could we get credit for the greater strength of our iron, they would rank one-third higher than English built.

The advantages of iron vessels are their strength, buoyancy, greater tonnage to given draught of water, and easier storage of cargo. The great disadvantage is, the action of salt water on the bottom—no paint or covering having yet been found which, at the same time, protects the iron from rust, and prevents the incrustation of barnacles and growth of grass. A list of the numerous compounds which have been patented for this purpose, and found almost utterly useless, would fill pages. But, even with this very great obstacle, the use of iron for the building of ships is every day increasing, even to such an extent that we may see in our port vessels whose cabin only is of wood—masts, spars, and rigging, all iron—and some with the decking also of that material. The advantage of these latter uses of the universal metal is not yet so evident, nor likely to become, for some time, so general as its use for the construction of the hulls. One of the ablest and most efficient con-

structors in our navy but a few days since remarked to us: "We have never yet built an iron vessel in any of our yards, and some have their doubts as to them; but, sir, we have got to come to it, we have got to come to it."

EXTRACTS FROM FIRST ANNUAL REPORT OF MASSACHUSETTS RAILWAY COMMISSIONERS, JAN., 1870.

THE EXTERNAL RAILROAD SYSTEM.

Hitherto, among us, public attention and the discusion of the press have been almost exclusively devoted to the condition of the external relations. The great Northern lines, the Hoosac Tunnel, the Boston and Albany and the Boston, Hartford and Erie roads have absorbed the public consideration to the exclusion of the internal system. If, however, the future of Massachusetts is bound up in the development of her manufacturing interests, such a method of observing the working of her railroads is very incomplete. The business of the through lines is, promptly and cheaply to keep up communication between ourselves and our producers and customers. Our railroads must perform on the one side what the sea does on the other, and it is perfectly immaterial to more than nine-tenths of the industry of Massachusetts, provided only it is done cheaply and certainly, whether raw material, food, power and manufactures come and go to and from the State by way of Ogdensburg or Baltimore, Albany, New York, or Portland. The Commissioners are satisfied that what has been done in the past in this respect as to supplying channels of communication for this purpose, leaves nothing to be desired. Five through lines now do or soon will connect Massachusetts with the West, and the perfect development of some single one of these lines is the first and absolute preliminary to a successful system of cheap transportation. Massachusetts has committed herself beyond recall to a policy of competition in this business. It is useless now to discuss, whether, for the necessities of her development, the wiser policy might not have been found to exist in the course pursued in Maryland and Pennsylvania,—in the thorough develop- of a single line, or of two single lines to different points, one being Albany and the other Ogdensburg. It is sufficient to say that this policy was not adopted, and that the contracts now in force in relation to tunnelling the Hoosac Mountain, and the aid already granted to the Boston, Hartford and Erie road, have placed the completion of those enterprises beyond the pale of controversy. It does not admit of doubt that if any one of the lines connecting Boston with the Hudson is ever developed to its full transporting capacity, it alone will suffice for the probable future wants of the people of Massachusetts; should the four lines between the same point and the Hudson or the lakes ever be developed, even to the present incomplete degree of the Pennsylvania Central, a population and foreign commerce could be sustained in Massachuetts and Boston more dense and larger than that of Liverpool and Belgium combined. If, however, the mission of the roads is primarily to supply the wants of a densely populated manufacturing community, and only secondarily to act as channels of foreign commerce, it is scarcely probable that they should ever be taxed to their full capacity. This is unfortunate, as it is a well established principle that the more roads have to do the cheaper they can afford to do it; and the converse proposition is no less true, that where the volume of business is limited, the more roads it has to sustain, beyond a certain limit, the heavier tax it has in the long run to pay to sustain them.

FARES ON THROUGH TRAVEL.

The accompanying table sufficiently exhibits the fares exacted on this branch of transportation in this country as compared with those on similar lines in different countries of Europe.

In examining this table, it must be borne in mind that the European rates of speed only apply to first class travel,—that of express trains;—the second and third classes travel at a rate much less than that indicated. The introduction of what are known as "drawing-room" or "palace" cars, supplies, as regards the American roads, in the table, the place of the European "first class;" and the ordinary

RAILWAY LINES.	Distance, in Miles.	Speed: Miles per hour.	FARES. First Class European and American Drawing-room Car. Gold.	Currency: Gold at $1.25.	First Class European: First Class American. Gold.	Currency: Gold at $1.25.	Third Class European: Second Class, or Emigrant American. Gold.	Currency: Gold at $1.25.	RATE PER MILE, IN CENTS. First Class European: American Drawing-room Car. Gold.	Currency: Gold at $1.25.	Second Class European: First Class American. Gold.	Currency: Gold at $1.25.	Third Class European: American Emigrant. Gold.	Currency: Gold at $1.25
London to Edinburgh........	400	38	$16 80	$21 00	$12 24	$15 32	$7 92	$9 90	4.20	5.25	3.06	3.83	2	2 50
London to Liverpool................	201	37	8 40	10 50	6 24	7 80	3 84	4 80	4.18	5.25	3 10	3.88	1.90	2.38
Paris to Marseilles.................	537	28	18 38	22 97	15 78	19 72	10 05	12 56	3.42	4.28	3	3.69	1.89	2.38
Paris to Brussels	228	35	7 14	8 92	5 36	6 70	3 70	4 65	3.13	3.90	2.33	2.90	1.60	2.04
Boston to Chicago...................	1,038	27	25 20	31 50	20 80	26 00	10 80	13 50	2.45	3.06	2	2.50	1.04	1.30
Boston to New York................	238	27	6 00	7 50	4 80	6 00	3 20	4 00	2.52	3.15	2	2.52	1.36	1.70

car, with which alone most of our roads are equipped, is entered on the table on the same footing as the European "second class," though it is infinitely superior in all respects. The cars entered as "third class" in the two countries are equally convenient. From this table it will be seen that the ordinary first class American travel between Boston and Chicago, or New York, is accommodated at the price established in England by law for the advantage of the poor classes, and that the American "palace car"—the most luxurious form of conveyance known in the world—costs the same in currency that the second class car in England does in gold. In every grade the advantage is strikingly in favor of the American traveller, both as regards comfort and expense. Whatever the future may bring forth, it is safe to say that nowhere in the world is the transportation of persons now so cheap as on some of the American through lines.

THE CARRIAGE OF FOOD, COAL AND RAW MATERIALS.

The great needs of this community in its present industrial phase, as has been already pointed out, are power, food and raw material; if these are adequately and cheaply supplied there need be no apprehensions of a declining prosperity. The interests of this community and of its railroad corporations, in regard to the transportation of articles coming under these heads—almost all of which come from beyond our limits as a State—would, if correctly understood, be found to be identical. The permanent value of our railroads to their stockholders depends wholly on the prosperity of the districts through which they run, and the prosperity of those districts directly depends, with us, on the command they have over raw material to feed and power to work their machinery, and food to sustain their population. These, constituting bulky freights, the roads should, with a view to their own interests, seek to supply at the lowest possible paying rates, and to draw their larger profits from the resulting prosperity. This cardinal point of policy they do not now seem fully to appreciate. Take for instance the case of Worcester. This city now contains 40,000 inhabitants, engaged in very diversified descriptions of manu-

facturing industries, all branches of which are dependent on power for the operation of their machinery. There is no reliable water power to be had, and the city is, therefore, forced to rely on coal from the Cumberland region, and from Pennsylvania, or from the Provinces. Every pound of this is brought to it by rail, and over 100,000 tons are consumed per annum. During the last year this amount was brought to Worcester in the manner and at the cost for transportation set forth in the subjoined table.

The Commissioners wish to call particular attention to the conclusions to be deducted from this table. The whole of the sum of money charged for this transportation is a tax on power, and a drawback on the prosperity of Worcester. Were the coal mined in the immediate vicinity of that city, and the transportation tax done away with, both Worcester and the railroads would be immeasurably more prosperous than they now are. As it is, the transportation tax is, to a great degree, a necessary and an inevitable one, and it only remains to divide it into its component parts of cost of transportation and profit, the profit representing the tax imposed for the benefit of the railroads.

There is no article of freight which admits of such cheap carriage as coal in bulk. In England, the rates upon it, as upon all other articles, are fixed by Act of Parliament, but they vary as regards the several companies. Two cents per ton per mile, for a less distance than fifty miles, is the usual rate, which does not include terminal handling. Very large profits are made by the companies transporting coal under this limitation. In two cases, at least, the cost of transportation has been analyzed with almost exactly the same result; the Eastern counties road claiming a profit of two-thirds while transporting at 10 mills per ton per mile, and the Great Northern a profit of thirty-three per cent. while charging 7 mills per ton per mile. The average English charge is 15 mills per ton per mile, which includes everything but terminal handling. On the nine principal French lines, for distances not exceeding fifty miles, the average charge is about fifteen per cent. less, or 12 mills per ton per mile. From a special report on coal, made by S. H. Sweet, Deputy Engineer, to the Legislature of New York, in 1866, it appears that the cost of transportation of this article on the roads of New York and of Pennsylvania, varied from 3.10 to 18 mills per ton per mile; the average cost on twenty roads in 1863 being 9.28 mills. This may therefore be taken as representing the cost of American roads in general. Those specified were mainly roads doing a large business in transporting coal; but it is to be remembered that the cost of carriage does not depend so much on the amount transported, as on the steadiness of the demand and the proportion preserved between it and the rolling stock employed. Wheels kept continually in motion earn a profit out of very low rates, even on a limited business.

RAILROADS.	Where from.	Number of Tons.	Distance in miles.	Over 5,000 tons to one person. Cost per ton.	Over 500 and less than 5,000 tons. Cost per ton.	Over 10 and less than 500 tons. Cost per ton.
Boston and Albany..................	Boston...........	6.143	44	$1 80	$1 80	$1 80
Norwich and Worcester..............	Norwich..........	51,621	60	1 75	2 00	2 25
Providence and Worcester...........	Providence......	46,424	44	1 75	2 00	2 25
Total	....	104,188	..	....	....	....

The distance to Worcester from tidewater is not over forty-four miles, but the roads leading to that city run through a region crowded with manufactures; the demand is steady and the business of transporting coal might be largely increased. The Commissioners are inclined to think that the present cost of coal carriage on these lines does not exceed, even if it equals, 14 mills per ton per mile, not including charges for terminal handling. 15 cents per ton at each end for these charges, the cost per ton from Boston or

Providence to Worcester should not exceed 92 cents, or $1.10, allowing a reasonable profit to the roads. The average charge during the last year appears to have been about $2.00 per ton, constituting a profit tax on warmth and power of nearly one hundred per cent.

The importance of this subject can best be illustrated by an individual instance. The Washburn Iron Company of Worcester receives old railroad iron and re-works it by a process of hammering and rolling, manufacturing car-wheels, locomotive tires and rails. Located as it is at Worcester, it must base all its calculations on being able to bring its coal to meet the old iron, at a less cost than the iron could be carried to the coal; it seeks in fact to make a profit by bringing coal to New England, instead of sending old iron to Pennsylvania. They consume about 18,000 tons of coal per annum, which is handled once by the railroads. Allowing the Providence and Worcester or Boston and Albany roads to charge 14 mills per ton per mile, the cost of one handling and fifteen per cent. of profit, amounting in all to 85 cents per ton, instead of perhaps $1.65, as at present, the annual power tax paid by this company would at once be reduced from $29,700 to $15,300, or by three per cent. on its entire stock capital. This may well make just the difference between success and failure. The city tax of Worcester for 1868 was $14.40 per $1,000 of assessed value. The Washburn Iron Company was assessed $218,200; if the city tax were permanently raised on this valuation from $14.40 to $80.00 per thousand, it would, most justly, be declared ruinous and the industry would leave the city. That identical increase is, however, now imposed in the shape of a transportation tax, and regularly paid under the name of freights on coal. It is unnecessary to dilate on the impetus which the reduction of this charge would communicate to the operations of the company referred to, or to estimate the increased amount of re-rolled iron, locomotive tires, car-wheels, travel and merchandise which would pass over the railroads in consequence of such an expansion.

No better illustration could be furnished of the harmony existing between the real interests of the community and its corporations. A cheap and abundant supply of all raw materials is at the root of the prosperity of each. For reasons which will hereafter be stated, no legislation can at this time be framed which will impose such a policy on the railroads, nor would it be wise to force it upon them were it feasible to do so. The Commissioners, however, confidently believe that not only will experience and reflection convince the railroads that the course suggested is the true one for them to pursue, but also that a more reflecting public opinion will compel them to adopt it, even though no recourse be had to the law-making power.

COMPARISON OF TURBINES WITH OTHER WATER-WHEELS.*

Translated from "Weisbach's Ingenieur-und-Maschinen Mechanik."

A great advantage of turbines compared with vertical water-wheels is that they work with any fall from 1 to 500 ft. (German), while the latter cannot convert into work the power of a fall of more than 50 ft. It is true that the ratio of effective work of turbines varies for different falls; for example, for small wheels it is less with high fall than with medium or low fall, because in this case the resistances are proportionally greater than with larger wheels under medium fall. On the other hand, overshot wheels obtain a modulus from high fall of from 20 to 40 ft., which cannot be reached by turbines. Equal amounts of work are to be expected from both kinds only from a medium fall of from 10 to 20 ft.; but if the fall is low, then turbines in every case give a greater modulus than undershot wheels under the same conditions. Poncelet's wheel can be compared with turbines for falls of from 3 to 6 ft. only.

Turbines have another great advantage over vertical water-wheels, in working with equal effect under different heads,

* Lehrbuch der Ingenieur-und-Maschinen Mechanik. Zweiter Theil: Statik der Bauwerke und Mechanik der Umtriebmaschinen (p. 668). This is the second part of Weisbach's book, the translation of which is now in press, to be published by D. Van Nostrand. Some idea of the completeness of the work can be had from the fact that the subject of Water-wheels occupies 285 pages, of which 153 refer to Turbines.

and especially in not being hindered by back water, so that they work in water as freely as in air, and in some cases with greater effect. Vertical wheels always lose power if the head varies, although in no great degree, unless the fall is low or the wheel is in the water.

On the other hand, variations in the overfall upon vertical water-wheels are attended with less loss of work than is the case with horizontal wheels. In an economic point of view this fact is in favor of the vertical wheel. If it is necessary to increase the effect of a vertical wheel already in motion, especially if it is one upon which the water acts mainly by pressure, it is done by supplying more water; and to diminish the effect the supply is partly cut off; in neither case is the actual modulus greater or less. The relation is altogether different in the case of a reaction-turbine. This works with most effect when the sluices are wide open and when the charge of water is the greatest; now if less work, and therefore less water, is required and the sluices are partially lowered, it happens that the work is diminished by decrease of supply, but partly by the loss of the living force of the water or by diminution of the head, so that the effective force is lessened. This destruction of living force may be compared with the braking or dragging of a wagon, which is applied in going down hill, when there is an excess of living force. Consequently, while the lowering of a gate only cuts off superfluous water from a vertical wheel, which can be used for other purposes; in the case of the reaction-turbine the shutting off a part of the overplus subtracts from the living force of the other part remaining in the wheel.

In pressure-turbines which do not run in water, so that the channels are not entirely filled, the modulus of work is more favorable, since the water issues through the channels without causing an eddy.

There is not a great difference between horizontal and vertical water-wheels in respect to the change of the velocity of revolution; in both, the normal velocity may be increased or decreased about one-fourth without material loss of effect. But there is certainly a very great difference in the magnitudes of these velocities. All vertical wheels, with the exception of the undershot (Poncelet's especially), have a maximum velocity of from 4 to 10 ft., while turbines generally have far greater velocities, varying greatly according to the heads. For this reason, and because they have smaller radii, turbines generally make many more revolutions than vertical water-wheels. It follows that the choice between these depends upon the number of revolutions; in other words, upon the kind of motion, quick or slow, which is required in the motor. But it must be borne in mind that rapid motion in a machine is rather injurious than advantageous, on account of the great increase of hurtful resistances, such as friction and shocks; for this reason it is often better to increase the number of revolutions by means of some machine of transmission, and to employ the vertical instead of the horizontal water-wheel.

If the load of a machine is variable, as in the case of tilt-hammers or rolling-mills, the vertical wheel is to be preferred; for, though it runs slower, yet on account of its greater mass it acts more as a regulator than the turbine, whose variable motion must often be equalized by a fly-wheel. But for a constant load preference must be given to the turbine in this respect; because vertical water-wheels, especially if of wood, often have a so-called "heavy quarter," *i. e.*, equal parts of the circumference are not of equal weight.

In an economic point of view, turbines rank at least equal with vertical wheels; and for high and medium falls and a great overflow, they are preferable because they are cheaper. In respect to durability, also, the turbine must have the preference.

On the other hand, it must be remembered that turbines require a clear overflow, and that their effect can be hindered in a very great degree by sand, mud, moss, weeds, leaves, pieces of ice, twigs of trees, etc., which do no damage to vertical wheels. Finally, it is to be considered that turbines, particularly those with guide-curves, are more difficult to construct, and that departures from the mathematical rules of construction are followed by worse results than in the case of vertical water-wheels. This is the reason that so many turbines failed in the early trials, and that they are not yet as extensively employed as their advantages warrant.

The Sutro tunnel has been bored seven hundred and fifteen feet.

METHODS OF SURVEYING.

By E. Sherman Gould, C. E.

There are several ways in which the form and area of a tract of land may be ascertained.

One method is by means of the chain alone. If the plan of any flat surface be examined, it will be perceived that it is possible to form upon it such a system of linear measurements as shall, irrespective of the value of the angles, determine the shape of its contour, and no other shape—the two conditions necessary and sufficient for the purpose proposed. It would be perceived, in such a plan, that the determining network consisted mainly in a system of triangles; the triangle being the only geometric figure the form of which is precisely defined by the dimensions of its sides, independently of those of its angles. It would be seen, moreover, that when the figure is not decomposed entirely into triangles, but is made up of triangles and trapeziums, it is necessary, in order that the figure be defined, that the trapeziums fall on the sides of the triangles, or on the sides produced.

From these considerations we deduce the following principles: First, that a chain survey is not practicable unless the tract to be surveyed admits of being decomposed into a sufficient number of triangles to tie the rest of its component parts together; and, secondly, that when accuracy in the computation of the area is desired, the entire figure must be reduced to triangles, having no trapeziums to be calculated off the plot. The determining triangles should be of large dimensions, proportionally to the size of the the tract, for mere tie lines do not afford a sufficient degree of accuracy.

I have said this much of chain surveying in order that its principles may be understood. Practically, it is a mere make-shift, to be used only when accidentally unprovided with instruments. It is neither so accurate nor so expeditious as when an angle-measuring instrument is employed in connection with the chain. In extensive surveys, obstacles will prevent correct alignements, and the whole work will be rendered uncertain.

The two methods of instrumental surveying are: *the system of co-ordinates* and *the system of traversing.*

By the first of these methods the form of the tract to be surveyed is determined by the location of a series of points on its contour, in reference to a *base line*, which may be one of the lines of the tract itself, but which is ordinarily an entirely independent and arbitrary line. The principle of this method is the same as the mathematical determination of a curve by the value of its *co-ordinates*, and I have presented the name for this method of surveying—there being, I think, no better introduction to the application of mathematical analysis to practical purposes than the familiarization of the mind with the actual signification of its technicalities.

Surveying by co-ordinates comprises two varieties: the one in which the co-ordinates are determined solely by the angles which they form with the base, and the other in which their linear as well as their angular dimensions are taken. Of the first of these I will not speak; its use is confined to the extensive triangulations executed for Government surveys, and is rarely applicable to ordinary purposes—for one reason, among others, that the success of such a survey depends on measuring the base line with a degree of accuracy unattainable with ordinary instruments.

The execution of a survey by the second variety of this method is exceedingly simple, especially when the co-ordinates are rectangular. Distances are measured on a base, to locate points whence to erect perpendiculars to the boundaries; and these perpendiculars, being measured, determine so many points on the contour, the minuteness of the survey depending upon the number of co-ordinates taken. When perpendiculars cannot be conveniently erected, recourse must be had to *oblique co-ordinates.* It will be seen that this method is chiefly applicable to cases where the distance from the base to the boundaries of the tract is comparatively small, otherwise the length of the ordinates, or offsets, would become excessive, and demand too much time and labor to measure.

The advantages of this method are:

1st. Its simplicity, both in the field and office work.

2d. Its general accuracy, which arises chiefly from the fact that any error in the measurement of an angle or distance does not affect the general result, being confined to that single observation.

3d. It accomodates itself to either minute or superficial work. By multiplying or diminishing the number of offsets, any desired degree of detail may be obtained, from a mere skeleton to a figure approaching the completeness of a mathematical integration.

4th. All the ground between the base and boundaries is taken cognizance of, as the points at which roads, streams, etc., are crossed may be measured on the ordinates.

All these advantages in the field work hold good in the office. It will be readily perceived in how convenient a form for plotting the field notes are taken, and the degree of accuracy in computing the area can be varied, as in the field work.

The disadvantages of the system are: 1st. That the work cannot be checked by closing. This difficulty, however, is rendered almost nugatory by the little likelihood there is of an important error being made, particularly when secondary offsets are taken, these serving as checks on the main co-ordinates. 2d. That it necessitates a previous knowledge of the "lay" of the land, in order to locate advantageously the base line and ordinates. 3d. That it requires generally the penetration in all directions of the tract to be surveyed, which is not always practicable.

The method by traversing consists in going around the tract, measuring the length of each side, and the angle which it forms with the one preceding it, or taking the distance and bearing of each side, if the instrument used be the compass.

The advantages of this method are, that it is applicable to any tract of land, of no matter what shape, and does not call for a knowledge of its lay. No reconnoitering is necessary, and the lines are "taken along" as you advance. In fact, by this method a survey may executed, checked, described, and the content calculated, without the surveyor ever knowing the exact shape of the tract surveyed. Its chief characteristic is, that the bounding lines are dealt with directly. These lines are naturally rarely obstructed by artificial obstacles, such as buildings, orchards, etc., and are therefore comparatively clear. Moreover, as such lines are generally intended to be perpetuated by a ditch or fence, the felling of such trees as may stand upon them is ordinarily permissible, which is not the case in running a purely arbitrary line, like a base or offset, through the middle of an estate.

This system is the one almost exclusively employed in this country, where indeed a method describing boundaries simply by their relations to each other, or by their bearings, is often indispensable. In England the system is but little pursued, probably because, in that thickly settled country, boundaries can always be fixed by well-known land-marks.

The radical defect of the system is its liability to lead to inaccurate results if the most minute precautions are not taken in the execution of the field work. Every line dates from the one preceding it (when the transit is the instrument employed), and a mistake in one not only affects all, but goes on increasing through the entire survey.

Nitro-Glycerine Explosions.—Much of the mystery that has surrounded the cause of many of the nitro-glycerine explosions, is now explained by the recent observation of M. Jouglet, who positively asserts that this compound, however carefully and well prepared, is subject to spontaneous alteration, whereby it becomes acid and disengages gas. This is doubtless the clue to the fearful explosions so frequently and unaccountably accompanying the storage and transportation of this material, and it at once suggests the true preventive of their recurrence. It should only be made on the spot when wanted, and in such quantities as its immediate use demands. Legislation is demanded in this country towards this end, as it has already been in England and some countries of continental Europe.

An excellent material for uniting water-pipes is prepared by combining four parts of good Portland cement and one part of unslacked lime, mixed together in small portions in a stout mortar, adding enough water to permit it to be reduced to a soft paste. Pipes thus united have been in use more than six years without repairing.

THE SECOND PERSIAN GULF CABLE.

From "The Bombay Gazette."

It may be remembered that more than a year ago the Government decided to submerge a second telegraph cable in the Persian Gulf, extending from Bushire to Jashk, on the coast of Mekran. At the present moment there is a double line of communication from Kurrachee to Jashk, the one by submarine, the other by aerial telegraph; and from Bushire to England there is the line by Turkey (just now unfortunately interrupted by the Arabs), and a second through Persia and Russia —the organization of which, at Messrs. Siemens' hands, will not, in all probability, be thoroughly carried out until the end of November. The laying, therefore, of the second cable between Jashk and Bushire will complete the duplicate chain of communication between India and Europe, and will relieve the old cable from a weight of traffic already nearly too much for its capabilities.

So far back as July, 1868, the manufacture was commenced in England, under the management of Mr. Latimer Clark, who was engaged to superintend the construction and submersion of the new cable. The general direction of the arrangements was intrusted to Major Champain, assistant to Colonel Goldsmid, the head of the Indo-European Telegraph Department. This is the first cable of importance where the old gutta-percha covered core has been discarded, and india-rubber, prepared by Mr. Hooper, the well-known chemist in Pall Mall, used in its stead. The superior insulating properties of the latter substance have long been recognized; but difficulties in properly preparing it, and numerous other causes, have hitherto prevented its general adoption. The excellent qualities of Hooper's core have, however, been satisfactorily proved by many severe tests. An experimental length has for a long time been laid near Bushire; the new core was also used for the existing Ceylon cable; many miles have been sent out to India for river crossings; and a considerable quantity was purchased and sent out in 1867 for telegraphic purposes during the Abyssinian campaign. The cable under consideration was covered by Mr. Henley, of North Woolwich, and shipped last winter on board the two fine-sailing vessels, the Tweed and the Calcutta. It was at first intended to lay the new line in the spring of the present year; but the whole arrangement had to be altered in January, in consequence of the disastrous collision of the Calcutta near the Lizard, when seventy miles of the cable had to be thrown overboard, and the vessel at last abandoned in a sinking state in Channel. The captain of the Calcutta and thirty of his crew, including three cable hands, lost their lives; but the ship was eventually picked up and towed into Plymouth by her Majesty's frigate Terrible. The seventy miles of jettisoned cable were grappled and recovered under the immediate supervision of Mr. Webb, Mr. Latimer Clark's assistant, and after great labor the Calcutta was able to sail again at the end of June, closely followed by the Tweed.

Both ships reached Bombay on the same day, and are now lying off the Apolla Bunder, preparatory to the final start for the Persian Gulf.

It was from the first determined to lay the cable out of sailing vessels in tow of steamers—a plan which involves some risk, and which is never adopted in latitudes where settled weather cannot be counted on. In this instance the vessel actually paying out will be towed by the Dacca, a steamer just chartered for the expedition by the Bombay Government. The second vessel will be towed by the Earl Canning, and the Amber Witch has already started for Jashk, to lay the shore ends in advance. The original length of 525 miles of cable shipped has been reduced by ten miles, in consequence of loss in splicing and repairing the seventy miles jettisoned off the Lizard. The operations will commence about the 1st of November, and the cable will be laid up the gulf from Jashk to Bushire, the Tweed first paying out her stock and the Calcutta completing the last half to Bushire. It is confidently expected that the ships will be back in Bombay by the beginning of December, to have their tanks removed and their decks and beams replaced.

TRUE BASIS FOR THE CONSTRUCTION OF HEAVY ARTILLERY.

BY LYNALL THOMAS.

(Continued from page 317.)

It has been assumed that the proper charge for a gun of given calibre should be proportional to (that is, as the cube of) the calibre; and so it might be were the effect produced by the repeated action of the charge on that portion of the chamber where the force of the charge attains its greatest magnitude relatively the same in guns of every calibre. But my experiments showed that this was far from being the case.

It is not the general pressure of the inflamed gas over the whole surface of the chamber, so much as the degree of energy expended in particular parts of it (or the magnitude of the strain at a given point at a given moment), which bursts or destroys a gun; and the latter I found by experiment to rise so rapidly in magnitude with any increase in the calibre of the gun (the charges being proportional) as apparently to preclude the employment of proportional charges, especially if the charge employed with the gun taken as a standard is the maximum charge which that gun is found to be able continually to bear.

Before the introduction of rifled ordnance, when round shot were exclusively used, it was necessary with guns of every calibre to employ charges proportional to the weight of the shot, or as the cube of the calibre, since the weight of the shot increased in that proportion; and if smaller proportional charges had been used with guns of larger calibre, the velocity of the shot, since the weight could suffer no reduction, would continually have been reduced, and the effect proportionally diminished.

And this method, up to a certain limit, could be carried out, because the charge necessary to give a 6-lb. or a 9-lb. shot its proper velocity (that is to say, the highest which it would practically bear with advantage) was so much smaller than a gun of its calibre and strength would actually bear. But smooth-bore guns having been apparently constructed on the "rule-of-thumb" principle, that is to say, as guns of different calibres were nearly all of the same relative proportions, the limit was soon attained; for we find that the charge for a 68-pounder gun, which is of about double the calibre of a 9-pounder gun, had a service charge of 16 lbs. only, whilst that of the 9-pounder being 3 lbs., it ought to have been 24 lbs.; and it is a remarkable fact that although the service charges for smooth-bore guns were in the proportion of the cube of the calibre, the proof charges were nearly as the square of the calibre only.

Now, nearly the whole of the conditions are different with rifled cannon, the weight of the projectile (within certain limits) being optional, as well as that of the charge of powder.

An entirely new element is thus introduced into all calculations relating to the construction and service of heavy artillery; namely, the proper regulation of the charge, first, with regard to the respective proportion of powder and shot, secondly, as to the quantity of either which can be used with the greatest advantage in guns of different calibres.

The actual effect of the charge and the proper thickness of metal (of a given quality) are the two essential points to be considered in the construction of heavy rifled ordnance.

In these days, when guns of great penetrating power are required, the proper regulation of the charge to the calibre of the gun is of the utmost consequence; and I think it will be generally admitted that the right charge to employ with guns of all calibres is the greatest that they will bear consistently with their endurance, not only as against actual disruption, but with regard to the effect of the repeated action of heavy charges on the surface of the bore, which will vary with the quality of the metal of which the interior of the gun is constructed.

Some years ago I carried out a set of experiments for the purpose of ascertaining, if possible, what was the maximum charge which steel rifled guns of different calibres would bear without injury; for a charge may be heavy enough, without absolutely and at once bursting the gun, to injure the interior or surface of the bore to such an extent that the repeated discharge of such a quantity will eventual-

ly cause the premature destruction of the gun, and (since the charge for guns of all sizes should be of a relative quantity, which shall allow them all to endure an equal number of rounds or discharges) must therefore be considered as too heavy for ordinary use.

The comparatively large quantities of powder which I found could be fired from tubes of small diameter, at first greatly astonished me. Charges of more than 5 oz. (with a round ball) were repeatedly fired in a tube ¾ in. in diameter (the size of the old musket-bore, the charge for which was 4½ drachms only) without causing any apparent damage, and of 1½ oz. with cylinders of over 7 oz. in weight. (I may state that the tubes were of a strength which insured them against actually bursting.)

For a moment I fell into the error that, beyond a certain quantity, the magnitude of the charge of powder could not be of the consequence I had supposed it to be, but was quickly undeceived; for, on further experiment with tubes of larger diameter, I was equally surprised to find that the length of the tube or bore occupied by the powder (the projectiles being of proportional weight, *i.e.*, as the cube) could not be materially increased. Instead of a quantity in the proportion of the cube of the calibre, it was found that a quantity proportional about to the square of the calibre only, was as much as the interior would apparently bear without injury.

The conclusions which alone could be formed from the above-named experiments coincided so nearly with those to which I had then already been led by observed results in a different set of experiments (on the action of gunpowder in chambers only) as to leave very little doubt on the subject. And if I have correctly estimated the results of these experiments, the proportion in which the charge ought to be reduced with any increase in the calibre is self-evident.

The limit for the charge will of course vary with the limit of endurance of the metal of which the interior of the gun is formed; the standard, therefore, will be raised or lowered with the quality of the metal, with the quality of the powder, and even with that of the metal of which the projectile is made. A general improvement in the quality of all these will tend therefore to greatly increase the power of heavy artillery.

If we are ever beaten by foreigners in the manufacture of heavy ordnance, it will be owing to the superior quality of their metal. The application of the twisted barrel (similar to that of the fowling-piece) to cannon was, no doubt, an excellent idea, and presents many advantages, but does not appear suitable for the inner surface of heavy guns, as not bearing well the repeated action of heavy charges and great friction, and is not in that respect to be compared with a hard close-grained homogeneous metal, like Krupp's steel, for instance.

If this is found to be so, the new 10-in. (18 ton) gun is not likely to prove eventually successful, since the charge which it is to fire (60 lbs. of powder and a 450-lb. shot) is equivalent, if I have rightly estimated the results of my experiments, to a charge of at least 24 lbs. of powder and a shot of 180 lbs. weight fired in a 7-in. gun. Supposing, therefore, that the service-charge for the latter gun, from 14 lbs. to 22 lbs. of powder and a 115-lbs. shot, is as much as the gun will continually bear, it is evident that the above-named charge for the 10-in. gun, as it must produce a comparatively greater strain on the gun, is too great.

In fact, if attempts are made to fire the same proportional charges which were formerly used with smooth-bore guns, namely, in the proportion of the cube of the calibre, either a different quality of powder or a different quality of metal will be required for every class of gun!

A knowledge of the law which regulates the action of the charge, and by means of which alone it is possible to form a correct estimate of the relative effect produced in guns of different calibres by both the powder and the projectile, is as necessary for the proper construction of a gun as is a knowledge of the laws of hydrostatics for the construction of a ship.

To the absence of this knowledge is due the enormous expenditure incurred during the last ten years in gunnery experiments. To it, no doubt, may be attributed the failure (which has been spoken of) of the attempt to apply the method proposed by Sir William Armstrong to large guns. The fact is, however, that the old system or theory was on its trial and signally failed; and whether applied in the case of

the Armstrong or any other method of construction, the results must have been equally disastrous.

Who could possibly form an opinion, for instance, as to the respective merits of the turret and broadside systems for ships of war, if so little regard were had to the laws of hydrostatics in their construction as to cause both but imperfectly to fulfil the proper conditions of ships at all?

The whole proportions of a gun are entirely dependent on the effect produced in the gun by a given charge of powder and weight of projectile; and of both the actual and relative magnitude of the effect in different guns the authorities, when first attempting to construct heavy rifled cannon, were confessedly ignorant. No formula for their construction was even attempted to be used; how, then, was it possible, except on the vaguest chance, to hit upon the proper method either for the construction or employment of heavy rifled cannon of any kind? It was proved to be impossible; hence the fruitless expenditure of so many millions.

As an example of the necessity, in gunnery experiments, of a previous knowledge of the law to which the action of the charge is subject, and the lamentable consequences which must ensue from neglecting or ignoring it, I may mention the attempt to strengthen (with a view to their conversion into rifled guns) the old 32-pounder smooth-bore service-guns, by placing a wrought-iron tube upon the exterior of the gun, so as to encase the breech part of it. The experiment failed, of course. It cost the country £45,000, which a little knowledge would have saved, numbers of these guns having been "strengthened" before the error was discovered, no preliminary experiments, apparently, having been made. Major Palliser, who has the reputation of being a scientific artillerist, and who at an early date had observed that the theory I had put forward respecting the action of gunpowder was borne out by experiment, placed the wrought-iron tube in the interior of the gun, and thereby added enormously to the strength of the latter. This may be understood by supposing that, were it necessary to protect a block of cast-iron from the effect of a shot's impact which would tend to split it, it is evident that a plate of wrought-iron placed at the back of it would prove no protection whatever, but that placed in front of it, where it could receive the first blow, it would effectually protect it.

The point at issue all along has been that the authorities have maintained that there is no law for the effect produced by the charge in a gun. The very nature of their experiments has proved that they hold this opinion, and that, necessarily, every class of gun must be made the subject of a costly set of experiments before it can be ascertained whether its proportions, charges, etc., are correct or not. "For every gun, no matter what its construction, there is a proper charge," was the opinion expressed to myself by one of the chief authorities in the War Department. It might as reasonably be said "for every ship there is a proper armament; it is useless, therefore, in building ships of war, to calculate beforehand what guns they are to carry; we shall find that out after they are launched!" And fancy no law or rule to exist by means of which this matter could possibly be calculated beforehand, and that every class of ship had to be the subject of experiments for years before the plan of its construction was decided upon! Yet this has been the case with our heavy artillery. And when it is considered into what an infinite variety of forms a given quantity of metal may be fashioned in its conversion into a gun, the expense, as well as the futility of making the gun itself the sole object of experiment, is apparent.

I have always maintained, on the contrary, that it is the effect produced by the charge to which experiment ought first to have been directed. The gun is merely the vehicle for the discharge of a shot of given weight with a given charge of powder. And if the proper laws are observed in the construction of a gun, of whatever kind it may be, that mode of manufacture is the best, no matter whether Frazer's, Whitworth's, Armstrong's, Palliser's, or Krupp's, which will allow of the employment in a gun of given calibre of the highest standard for the charge.

It was with the view of attempting to prove the truth of what I had advanced, as well as to show the great power attainable with heavy rifled artillery, firing charges in conformity with the results obtained in my experiments, that I had the first 7-in. and 9-in. guns constructed.

The 7-in. was the trial gun. The principle upon which it was constructed was

so novel, and the whole undertaking deemed so rash, putting aside the facts that so heavy a gun (6½ tons) was said to be perfectly useless (since no ship could ever be made to carry them), that no rifled cannon larger than a 40-pounder Armstrong gun was ever likely to be used, and that a gun of this size even had not yet been successfully made, that I was informed that I must undertake the whole cost at the risk of an entire loss in the event of failure. Notwithstanding the large sum I had spent upon it, and the sinister prognostications that the shot could never be got out of the gun, I fired at once charges of a quantity relatively very much in excess of any which had ever been attempted previously in any kind of gun,—the smoothbore gun of that calibre firing charges of 14 lbs. with a 42-lb. shot only.

The charges were from 23 lbs. to 28 lbs. of powder, and the shells (expanding) of 175 lbs. weight*; and the practice at once showed the enormous results attainable with guns on this principle.

The gun, which was of steel and forged in one piece (the largest which had ever been attempted), was unfortunately found to be defective in the breech, and at the second trial burst whilst firing a charge of 21 lbs. only; and I lost a large sum of money by it, as the repayment of my expenses was on this account refused.

I have not referred to this trial, however, for the purpose of detailing my own grievances, but to show that the principle was correct, since subsequent trials with guns constructed in conformity with it have proved so successful that, singular to say, a gun of the identical weight and calibre is now adopted into the service, the only difference being that the charges are not quite so high as those I first proposed, which were from 20 lbs. to 25 lbs. of powder, the highest charge used with the 7-in. service-gun being fixed at 22 lbs. and a shot of 115 lbs. weight. Unhappily, the authorities were unable at that period to appreciate the importance of the results which attended the trial of the 7-in. gun, chiefly from the fact that they were totally inexperienced in all that related to heavy rifled ordnance. Unfortunately, too, our gunnery experiments were begun at the wrong end, attention being chiefly directed to merely mechanical improvements before a sound principle had been established as a basis to work upon. Hence the enormous expenditure which they have occasioned of late years.

It is far from my wish to impute blame to any person, but no one can doubt that a great error was committed and lack of judgment displayed in the first instance.

The old "rule-of-thumb" principle was all very well when applied to cast-iron guns of comparatively small weight and power; but the attempt which I first made (in conformity with laws obtained from previous experiments) in 1858 to introduce heavy rifled guns firing huge cylinders with large charges of powder, caused a complete revolution in artillery by introducing entirely new elements for consideration, which rendered it absolutely necessary that some fixed laws should be established, both for the construction and use of these guns; and when we consider that there is scarcely a single law in dynamical science which is not involved in this question, it may be imagined how necessary this must be, and also how expensive and profitless experiments with this kind of ordnance must be (since no correct estimate can be formed of their value) until this has been satisfactorily effected.

Our enormous expenditure in experiments with heavy rifled guns may be said therefore to have chiefly arisen from the circumstance that, instead of those experiments being primarily directed to the establishment of sound fundamental principles, they seem to have had for object simply the improvement in the actual mode of manufacturing cannon, a course which has been more profitable to the manufacturers than to those who have had to pay the expenses; consequently attention has been mainly attracted to niggling mechanical details, upon which any given sum may be frittered away, and which, after all, are only of secondary importance. When once a sound basis has been obtained to work upon, mere mechanical experiments work themselves out in

* Expanding shot are productive of greater strain on the gun, though not to the extent usually supposed; for although an apparently large pressure is necessary simply to push them through the bore, yet as a comparatively slight but sudden blow will drive in a nail which would resist a large pressure, so the force of a charge of powder, being percussive, drives out the projectile by an action the value of which cannot be estimated by any given number of pounds weight. In fact, it is questionable whether the strain produced by expanding shot (of soft metal) is in any degree greater than is due to the circumstance that with such shot there is a complete absence of windage.

the course of practice; but if guns are constructed on a principle which is fundamentally wrong, however admirably the mechanical details of their manufacture may be, proper results are absolutely unattainable with such.

The authorities point with satisfaction to the mass of heterogeneous results obtained during the experiments of the last ten years, as if they had thereby exhausted the subject; but of what, may I ask, have they been productive?

As a proof of the small value of mere results, and of the errors even to which they may give rise unless judged on sound principles, I may cite the following:

In 1862, Lieut.-Col. Boxer, of the Royal Artillery, wrote a pamphlet, entitled "Remarks on the system proposed by the Royal Commissioners for the Defence of the Country," which was replied to in another pamphlet by Colonel (now General) Lefroy, R. A., President of the Ordnance Select Committee. In the former, certain statements were put forward with regard to the effect producible theoretically by projectiles of equal weight, but different diameter, on iron plates; which Colonel Lefroy attempted to show were contrary to the results obtained in experiment, and therefore erroneous.

"Perhaps (remarks Colonel Lefroy) the best way of showing the fallacy of the assumption that the penetration of two shots into wrought-iron, the *vis viva* being equal, will be inversely as the squares of their diameters, is to see to what this assumption leads.

"Suppose the 110-pounder shot reduced in diameter to 3 inches, *i. e.*, to take the form of a cylinder nearly of the weight of ten shots fired from a 12-pounder gun, but with such a charge as will give it the same velocity of impact as before. According to this rule, its penetration should be 5.3 times as great; now the mean penetration, or denting, of wrought-iron by the 110-pounder shot at 200 yards is 2.1 in.; we are entitled, therefore, to assume that such a bolt will produce a dent of 11.2 in., and of course *go through* a greater thickness of iron, just as the 110-pounder would go through more than 2.1 in. Lieut.-Colonel Boxer can maintain no such absurdity, and he is well aware that the work of the blow would be mainly done on the shot itself, which would go to a hundred pieces, while the effect on the plate would be probably but little greater than that of the common 12-pounder shot. * * * * Hence a 110-pounder shot reduced to a diameter of 13 in., would produce very much *less* effect than in its original form with a diameter of 7 in., the reverse of what Lieut.-Colonel Boxer would lead his readers to expect."

The above affords an excellent instance of the truth of what I have stated. Col. Boxer based his arguments on a well-established scientific law; Colonel Lefroy, on certain results he had witnessed in experiment.

Colonel Lefroy, being President of the Ordnance Committee, it may reasonably be supposed that the 10.5 in. (300-pounder) 12-ton gun was constructed in accordance with the above-named experimental results. Let us suppose, therefore, that at that point all Government experiments had ceased, and the order had gone forth to construct the whole of our rifled ordnance on the plan of the above-named guns—that is, in conformity with the experimental results already obtained; what would have been the consequence? We should have made an enormous outlay in the acquisition of guns on a totally wrong principle, and been years behind the rest of the world; for the very next year my first 9-in. gun, firing charges of from 40 to 50 lbs. of powder and shot of proportional weight, was fired with the Government 10.5-in. gun for the first time against 7½-in. plates (steel shot of equal weight being employed with both), when the penetration of the 9-in. shot was 10½ in., whilst that of the 10.5-in. gun was 6½ in. only.

A few years later Major Palliser brought out his chilled shot, when the comparative penetration of projectiles of small diameter was greatly increased. How, then, may it be asked, could the actual results of experiment have been apparently at first so directly opposed to those established laws upon which Colonel Boxer grounded his arguments, and which subsequent experiment tended to confirm? Simply because the first results were misjudged; since, instead of proving (as inferred by Colonel Lefroy) that with projectiles of the same weight those of larger had greater penetrating effect on iron plates than those of smaller diameter, they proved merely that the metal of which the pro-

jectiles were composed was of too soft or too friable a nature to admit of their being projected with a force sufficient for the purpose; consequently the smaller the diameter of the shot compared with its weight, the more apparent was this defect, and the greater the visible damage produced by the impact of the shot of larger diameter.

Colonel Boxer therefore was perfectly right in taking the grounds he did, and Colonel Lefroy's experimental results no more tended to overthrow his arguments than would the results obtained by firing a Dutch cheese against iron plates; it would simply have been a question of the degree of hardness of the projectile; and this shows how very much more important is the establishment of a single scientific truth than the mere acquisition of millions of undigested results acquired in desultory experiments.

FILTERING AIR.

From "Engineering."

Everybody is familiar with the sight of "motes dancing in a sunbeam," and there are probably few people who have not at some time or another, when looking at these minute particles, reflected that the air we breathe is apparently rather a dirty mixture, after all. And—to a certain extent—people are perfectly right when they make this reflection. The air in all towns, and, to some smaller extent, in the open country also, is impregnated with these minute atoms, invisible in ordinary diffused light, but revealed when exposed to a powerful beam of solar or other light, by the dispersion of this light to which they give rise. Until about eighteen months ago it was generally believed that these minute particles consisted of inorganic matter, and that they were indestructible by the ordinary process of combustion. In October, 1868, however, Professor Tyndall, who was at that time experimenting on the decomposition of vapors by light, discovered that air, when allowed to pass through the tip of the flame of a spirit lamp, was deprived of these floating particles, the latter being in fact consumed, thus showing their organic character. Prior to this discovery, Professor Tyndall had endeavored to filter the air of these atoms by passing it successively through two glass tubes, the one containing fragments of glass moistened with sulphuric acid, and the second fragments of marble moistened with caustic potash; while in other cases he had allowed it to bubble up through the liquid acid and through a caustic potash solution. In both instances, however, the air passed through carried with it the minute particles, these being clearly revealed by the light of a condensed beam. Having discovered, however, that the atoms could be burnt up by being made to traverse the flame of a spirit lamp. Professor Tyndall substituted for the latter a roll of platinum gauze, placed in a platinum tube and ignited to redness; when he found that equally good results were obtained, the air being cleared of its floating impurities. But the air can be filtered of its floating particles by other means than by combustion, and Professor Tyndall has found that a thoroughly effective filter for this purpose is formed by a layer of cotton wool, not too tightly packed—a form of filter, we may add, that was first used by Schroeder, in his experiments on spontaneous generation.

But, it may be said, this is all very interesting, no doubt; but what has it to do with engineering? We answer—a great deal. Of the many branches of our profession there is none of greater importance than that dealing with sanitary questions—such, for instance, as the disposal of sewage, ventilation, and subjects of a kindred nature. In a civilized community, life itself depends upon the satisfactory solution of the problems which these subjects involve, and there is certainly no necessity for us to enlarge upon their importance here. Now, Professor Tyndall has shown that the atoms floating in the air are of an organic nature, and he has, moreover, shown that when air is passed through the lungs, it is to a certain extent deprived of these atoms, a portion of the latter evidently having been retained within the lungs themselves. Moreover, in an admirable lecture on "Dust and Disease," delivered by him at the

Royal Institution, on Friday last, he has shown—reasoning from analogy—that there is a strong probability of what is known as the "germ theory of epidemic disease" being, at all events to a great extent, correct. According to this theory, which, proposed many years ago, was at one time treated with strong opposition and ridicule by the medical profession—epidemic diseases are propagated by floating germs which enter into the system and give rise to parasitic life. Supposing this theory to be correct, and, as we have said, there are strong reasons for supposing it to be correct to no small extent, it evidently becomes one of the first duties when endeavoring to prevent the spread of disease, to deprive the air of these floating germs by some process of filtering. And here we may remark that this filtering process is almost instinctively resorted to by our medical men, it being a common thing for a physician, when visiting a patient suffering from a contagious disease, to place a handkerchief to his mouth and breathe through it. To some extent, this handkerchief, as has been shown by Professor Tyndall, answers the purpose of cotton wool filter, depriving the air of its floating atoms, and allowing it to enter the lungs in a pure state.

But even if an epidemic was raging amongst us, the majority of people would object to go about with a handkerchief over their mouths, or wearing a cotton wool respirator, and indeed the ordinary demands of business would prevent these precautions from being generally resorted to. It is here, then, that the sanitary engineer steps in to the aid of his medical brethren, it being his duty to do on a wholesale scale that which personal safety would require each individual to do for himself. In other words, supposing the germ theory to be true, it is his duty to filter all air escaping where disease is active, or where the germs exist, thus preventing the dissemination of the latter, and hence the propagation of disease. Thus the ventilating flues of hospitals devoted to contagious diseases, the openings of sewers, etc., should be guarded by filters which will arrest these germs, while it is probable that in the ventilation of churches, schools, or large public buildings, also, the air admitted and discharged might be advantageously submitted to the filtering process.

Of what the filters could be best composed, it is as yet impossible to say. The cotton wool filters, shown to be so effective by Professor Tyndall, might be employed in some cases; but in a vast number of instances there would probably be practical objections to their use. The efficiency of the cotton wool filters is likely to be due to the enormous collecting surface which the filaments of cotton, contained within a moderate compass, expose, and it is not unlikely that charcoal or other filters, such as are now used, would, if made so as to expose an equal amount of surface, act equally well. So far as we are aware, however, no experiments have yet been made upon the power of charcoal to retain the atoms floating in the air, but the experiment is easily made, and should be carried out without delay. In some cases the passage of the escaping air through fire, already a well-known disinfectant, or over highly-heated surfaces, may prove the most convenient mode of treatment; but where the air has to be purified before admission to a building, this plan is manifestly not applicable. The action of vegetation on air charged with atoms, is also highly deserving of investigation, and such an investigation might do much to dispose of the objections which have been urged against sewage irrigation.

The test of the efficiency of a filter, of course, is that the air issuing from it shall, when traversed by a powerful ray of light, not render that ray visible to an observer standing out of the line of it. In fact, air cleared of its floating atoms is not illuminated, in the ordinary sense of the term, by a passing ray, and a current of such air, when caused to cross a sunbeam, which is passing through ordinary air charged with atoms, appears to break the continuity of the beam, the current, which is clear of atoms, showing on the beam like dark smoke.

We have devoted considerable space to the matter of which we have been treating, because—notwithstanding that the "germ theory" is not yet a firmly established fact, and hence the benefits derivable from filtering air not yet decisively proved—the subject is one of such vast importance that it cannot be too widely or too thoroughly discussed. That our sanitary engineers have already done very much to restrain the spread of disease, we

are quite ready to admit, but the terrible records published year after year by the Registrar-General, prove that there is yet much to be done, and everything that tends to the completion of this great work is worthy of sincere encouragement.

THE ISTHMUS OF CORINTH.

From "The Engineer."

Perhaps, as a rule, it is not generally admitted or recognized by engineering students, as well as by other professional *alumni*, that physical geography is a very interesting and instructive science. To the unlearned and uninformed a glance at the map of the world reveals nothing but a somewhat chaotic distribution of land and water. The mutual relations and the several positions of the "dry land," and "the gathering together of the waters," appear to be accidental, and at first sight there is no evidence of any method in their respective arrangement. But a very slight acquaintance with the science to which allusion has been made, will demonstrate the fallacy of such an opinion; and indicate in unmistakable language that the physical contours of our planet have been determined by the unerring laws of nature. As a corroboration of our assertion, it is quite sufficient to mention the general uniformity that is to be observed in the shape of continents and large masses of land, which are laterally extended towards the north and contracted in the south. It is well known that whatever other grounds Columbus might have had for believing in his own mind that the New World existed, his belief was materially strengthened by his knowledge of physical geography. An attentive observation of the manner in which the land and water was arranged, and the balance of matter maintained, led him to the conclusion that there must be a large mass of land somewhere in the Western hemisphere, to counteract the influence of so extensive an area of water. The result of his reasoning was the discovery of America.

Regarded in the abstract, it is scarcely possible for the comparatively insignificant efforts of man to alter the physical appearance of the globe. In one sense, however, they do very materially change the face of the earth, and there is very little doubt but that it is a mission of the human race so to do. It is true that our power is limited. We shall never fill up the Atlantic Ocean, nor level the Himalayas, but we do form rivers, destroy enormous forests, and drain lakes. Nothing would be easier than, by making a communication with the nearest ocean, to convert some of the most beautiful and fruitful valleys of the world into inland seas, and make them like unto Sodom and Gomorrah. There is neither presumption nor the least approach to profanity in asserting that modern engineering is the only art that makes "the crooked straight and the rough places plain." The argument that "the end justifies the means" has always been regarded as rather of a Machiavellian character, nearly identified with doing evil that good may come of it, and by no means a safe maxim to instil into the minds of youth. It is, nevertheless, astonishing how sometimes the end does justify the means, and how success is invariably regarded as the test of merit. This has been remarkably exemplified in the completion of that great work, which will deservedly entitle the name of de Lesseps to be recorded in the historic archives of every kingdom under the sun. Henceforth the means of executing similar works will be disregarded; the motto will be *Finis coronat opus;* and a mania will arise for cutting through isthmuses, which will give employment to every navvy that can handle pick and shovel. The physical subdivisions of the land will consist in future of islands only. What joy for the rising generation and the pupils of national schools! Continents, isthmuses, and peninsulas will be banished from the text-books, and juvenile brains will be no longer puzzled to comprehend the several distinctions.

At this particular moment, when the opening of the Suez Canal has attracted universal attention towards all those narrow necks of land which divert vessels from a direct course, it cannot fail to strike one that the railway has not altogether superseded the canal as a means of international communication. In the instance

before us we have railway and canal occupying the same territory. Were the executive of a Government always equally quick in its operations as the administrative department, the modern Athenians would be the first to follow the example of M. de Lesseps. The Hellenic Parliament is in deliberation respecting the cutting through of the Isthmus of Corinth, the tongue of land which is situated between the gulfs of Athens and Lepantus and unites the classic mainland with the shores of the Morea. By its geographical position, this isthmus bars the union between the Adriatic and the Archipelago, and obliges all vessels passing from the one sea to the other to round Cape Matapan. Its existence materially lengthens the voyages of all ships bound from the western parts of Europe to the Levant, to Syria, Asia Minor, and to Smyrna. The last-mentioned port is the emporium to which the numerous caravans from the interior of Asia, from Persia, and the Caucasian regions, transport the rich products of oriental countries still more distant. In a similar manner it exercises a protracting influence upon the route from Europe to the Black Sea, which is a matter of serious importance, as from the ports on the latter are exported the enormous quantities of wheat and other cereals which supply a considerable portion of our own continent. The junction of the waters of the Adriatic with those of the Archipelago would effect a saving in time of two days in the voyage from the harbors of Brindisi, Ancona, and Trieste, to the Levant. It would also greatly facilitate the establishment of local traffic, and probably lead to the adoption of a regular system of steam communication of which Greece is very much in want. At present the coast is not particularly well furnished with harbors, but those that do exist are capable of both improvement and extension. Moreover there is every inducement to construct new ones, as the adjoining bays are deep and afford a secure anchorage for vessels of heavy tonnage.

The present project is a revival of a similar one entertained in the days of the Roman emperor, Nero; and considering that the obstacles in the way of its accomplishment are comparatively few and insignificant, it is somewhat astonishing that the enterprise has never been carried out. Probably the miserable state of decadence and abject inferiority into which the country fell, totally debarred all such attempts. The extreme points of the Isthmus of Corinth are Heapolis and Kalamakis, and supposing them, like Suez and Port Said, to represent the respective mouths of the intended canal, its length would not exceed three miles at most—a very insignificant cutting, so far as the actual lineal dimensions are concerned. It was anticipated, and experience has now demonstrated, that the nature of the material through which the Suez Canal is excavated, will constitute the principal and possibly the sole difficulty to be contended with in future. As it is, the reduction of the present batter of the side slopes is imperative. If not performed by excavation, the operation will proceed spontaneously by the gradual sliding of the sand into the water, whence it will be removed by the dredgers, which, under any circumstances, will have a busy time of it for some years to come. Fortunately, this difficulty does not exist in the projected canal in the Morea. The earth is of a tenacious character, which will offer a better resistance to the disintegrating action of the water agitated by the passage of ships and the motion of screws and paddles, and thus reduce the cost of maintenance and repair. It has been estimated that this important work can be carried out at the moderate cost of half a million. Without taking into account the number of contingent steam and sailing ships which would avail themselves of the passage *via* the Corinth Canal, there would be a regular traffic of the boats of the Messageries Impériales, of the Company of Marseilles, of those of the Austrian Lloyd's, and of those belonging to the Italian service. The total of these would be quite a sufficient guarantee for the investment of the capital required. Were the work once executed, Kalamakis, which at present is but a village, would speedily become a maritime town of importance, and numerous cities, long since abandoned, and, as it were, buried, would be disinterred, restored to life, and ultimately constitute commercial centres from which to export the mineral wealth with which the country abounds. The welfare and prosperity of every nation are in direct proportion to the means it possesses for facilitating its internal and external commerce. No people are in greater want

of these means than the Greeks, and the wisdom of the attempt to obtain them by a ship canal in the first instance, will be apparent to every one who is acquainted with the physical character of the country, and the many obstacles they present to the introduction of railways and even of common roads.

HIGH CLASS STEAM ENGINES.

From "Engineering."

We were greatly amused a few days ago at seeing, in the columns of a contemporary, "the most economical engines, so called, because they burn little coal," defined as those with "a multiplication of moving parts, often accompanied by bad design, bearing surfaces deficient in area, and a general lack of strength in the parts, and of fitness to the intended purpose." There was a freshness and originality about this definition which took our fancy mightily, and we have quoted it here because it serves to describe—as clearly as words can describe—just what we consider a "high class" steam-engine ought *not* to be. We should ourselves rate as of a high class, an engine provided with all the appliances necessary to true economy, having all its details well proportioned, and having no part which did not serve some useful purpose. It is as great a mistake to suppose that an economical engine must necessarily be complicated as it would be to imagine that an engine which is of complicated construction must therefore be economical. As we pointed out in a recent number, no "improvement" should be applied to an engine unless—under the particular circumstances under which the engine is worked—its employment will effect a clear annual saving more than sufficient to pay a proper interest on the extra capital sunk in its first cost; and the true economical value of any "improvement" will be represented by the excess of the annual saving it effects above this interest—any extra cost of maintenance being, of course, duly allowed for. The higher the price of fuel at the place where the engine is worked, and the greater the number of hours per annum during which the engine is kept running, the greater, also, will be the expenditure which it will be justifiable to make on "refinements," as they are called by some engineers; and those who have gone into the question carefully, well know that the occasions are very rare where these "refinements" can be neglected without wasteful results ensuing.

Notwithstanding these facts, well known as they are to competent men, there is a certain class of individuals to whom most "refinements" are abominations. They will permit the use of a steam jacket, perhaps—probably because when once the engine is erected, this jacket is out of sight, and consequently, according to the old proverb, out of mind—but any refinement that necessitates a moving part, is a terror to them. A bar of iron or steel—no, we beg pardon, not steel; steel to these people is as as yet a new and untried material—may, according to these "engineers," be employed as an ordinary slide-valve spindle, and may move backwards and forwards for years without risk of failure; but attach it to an expansion valve, and—woe to the unhappy mill-owner!—it may break any minute, and great and disastrous will be the loss incurred by the consequent delay. Really, when we think of all this, we are almost lost in admiration at the unrecorded heroism of the hundreds of factory proprietors and steamship owners who have for many years past actually used engines with expansion valves, notwithstanding the awful consequences the latter involve. Our admiration, however, is diminished when we remember that these people are infatuated, and that they actually believe that by using engines of a high class, and thereby effecting a considerable annual monetary saving, they are doing rather a good thing for themselves than otherwise. The "anti-refinement" engineers, whose opinions we have expressed, however, know better than this. They feel assured that the crash will come sometime, and that then they will be glorified.

It is melancholy to consider how few of these "anti-refinement" gentlemen have a chance of being thus glorified during their lifetime. Hundreds of engines, such as they condemn, go on working day after

day and year after year, with most provoking regularity; and although failures *do* take place, yet they are but few and far between, and certainly the percentage of such breakdowns is not greater than—if indeed it is as great as—it is with engines of the very plainest construction. Judging from these facts, we are led to believe that the "anti-refinement" class of engineers must be blessed with Zadkiel-like powers, and that their utterances refer not to things of the present, but to things to come. If this supposition be correct, and *if* their prophetic powers are also of a reliable character, then their sons, or grandsons, or great-grandsons, or great-great-grandsons, may be gratified by beholding the disasters that their forefathers had foretold—always supposing that the said forefathers and their predictions had not been totally forgotten in the meantime. This is a serious matter, but as men don't believe much in prophetic powers nowadays, we fear that the present generation will go on using economical engines, and that the certainty of present profit will have more influence with them than the doubtful possibility of future calamities. Inasmuch, however, as there may be some users of steam power who, having a strong affection for posterity, may wish to benefit (?) future generations by following the precepts of the "anti-refinement" clique, we have compiled to the best of our ability a few axioms which embody those precepts, and which may be of use to those wishing to adopt them. These axioms are as follows:

1. It is very wrong—we had almost written wicked—to use *any* moving parts in a steam-engine. But inasmuch as you must use *some*, use as few as you can, and never mind if you could get more economical results by using a greater number.

2. It is very wrong to build double-cylinder engines. Such engines have "two or three sets of slide and expansion valves;" and although in so many instances they have apparently given such good results, this is merely a deception, and is more than counterbalanced by their great internal friction.

3. Cornish engines are "excessively simple." [In order that the reader may appreciate this axiom thoroughly, he is recommended to study working drawings of a set of "Cornish" valve gear, including the cataract, and he will thus learn how an "excessively simple" engine may be made.]

4. Engines using 22 lbs. of steam per indicated horse power per hour are "huge scientific toys," the size of the engine not affecting this statement. It is wrong for grown-up people to play with toys; therefore such engines should not be built. The fact that they do their work well and economically is of no consequence.

5. The fact of economical engines requiring less boiler power is not to be taken into consideration in estimating the relative first cost, or cost of maintenance, of "high class" and ordinary engines.

6. "When an engine has but 10 or 12 hours to work out of the 24, when it is lightly loaded, when it is placed in the hands of first-rate attendants, and when coal is very dear, the introduction of a great deal of complication may be permissible." Taking the "excessively simple" Cornish engine as a groundwork, a complicated engine may be easily designed to suit the above circumstances.

We could, if our space permitted, give many more such axioms, but we must refrain, as, before concluding this notice, there are two matters, both relating to the double-cylinder engine, of which we desire to say a few words. These matters are: first, the idea which exists, even in the minds of many engineers who ought to know better, that the internal friction of a double-cylinder engine is greatly in excess of a single-cylinder engine of equal power, and equally good construction; and, secondly, the idea which is also prevalent with some people, that the "duty" of a double-cylinder engine is more likely to fall off as wear of the parts takes place, than is the case with a single-cylinder engine. Now we are of course perfectly aware that in the double-cylinder engine a certain amount of extra friction is caused by the use of an additional piston, and of two or perhaps three additional stuffing boxes; but in reality this extra friction forms an insignificant portion of the whole internal friction of the engine, even when the latter is running light. When the engine is working with a load, the percentage of extra friction due to the extra piston and stuffing boxes is still further diminished, for of course the friction of these parts is not increased by the load itself as is that of the crosshead guides,

crank shaft bearings, etc. Against the extra friction just mentioned must be set—supposing balanced valves not to be used—the diminished friction of the slide valves in the compound engine. The friction of a slide valve is due, first to the difference between the pressure in the valve chest and that in the exhaust cavity; and second—during a portion of the stroke—to the difference between the pressure in the valve chest, and that in that end of the cylinder in which the steam is expanding, this difference of course acting on the area of the port covered by the valve. If now the two slide valves of a double-cylinder engine were each of the same size as that of a single-cylinder engine, the total friction due to the first of the above-mentioned causes would be the same in both cases, the only difference being that in the double-cylinder engine the total difference of pressure would be divided between two valves instead of acting upon one alone. In reality, however, the two valves of a compound engine are not each of the same size as that of a single engine of equal power, one being smaller, and hence there is a saving of friction. Again, in the compound engine the cut-off of the steam of course takes place much later than in a single-cylinder engine working with the same degree of expansion, and hence the unbalanced pressure on the valves due to the second of the above-mentioned causes is less, and the friction is consequently less also.

Next as to the deterioration of "duty" caused by wear and tear. And here we may state that there is no excuse for leaky joints in either single-cylinder or compound engines. Pistons and valves, however, will leak sometimes; but in these cases compound engines have a decided advantage on account of the less effective pressure to which their parts are subjected. Thus in the case of the valve and piston of the high pressure cylinder, the pressure causing leakage is only equal to the difference between the boiler pressure and that at which the steam is discharged into the low pressure cylinder, while in the case of the valve and piston of the latter the maximum "leakage pressure," as we may call it, is equal to the difference between that at which the steam is received from the high pressure cylinder and that existing in the condenser. The weight of steam that would be allowed to pass to waste into the condenser by a given amount of wear in the pistons or valves, is therefore much less in the case of a compound than in that of a single cylinder engine, and this fact goes far to explain the excellent duty which the former engines undoubtedly do give even when considerably out of order.

The Prussian Government has military maps of every foot of its territory so complete that every hill, ravine, brooklet, field, and forest is delineated with perfect accuracy It is a common boast of Prussian military men that within the space of eight days 848,000 men can be concentrated to the defence of any single point within the kingdom, and every man will be a trained and well-equipped soldier.

Fairlie Engine.—A double bogie eight-wheeled 24-ton Farlie engine, built for the Nasjo and Oscarsham Railway in Sweden, was tried on Monday on the Ring Railway of the Fairlie Engine and Steam Carriage Company at Hatcham, in the presence of the Duke of Sutherland and about forty gentlemen and practical engineers. The engine was run round the curves of 50 ft. radius, at the speed of 20 miles an hour.—*Engineer.*

Blast Furnaces.—It is estimated that in England 500 blast furnaces are reducing by their intense heat nearly 12,000,000 tons of iron ore to 4,800,000 tons of metallic iron, which, at its place of production, has a value of about £11,000,000 sterling. Those blast furnaces consume more than 14,000,000 tons of coal; and, to convert the pig-iron obtained into bars, rails, etc., a like quantity of coal is required. In France the great iron industry is no less active. The works of Messrs. Schneider and Co., at Creusot, the largest in France, have 50 acres under cover. Here are 15 blast furnaces, with 27 steam-engines blowing air for them, and forging iron besides. At the mines and works over 3,500 men are employed. In Belgium, at the works of the Company Cockerill, near Liége, 7,400 work-people are employed.

THE PROPERTIES OF MALLEABLE CAST-IRON.

BY DR. ADOLPH OTT.

From the "Journal of Applied Chemistry."

The increased flexibility of malleable iron, according to Mr. R. Mallet, is to be attributed to the fact that small crystalline scales of graphite are uniformly disseminated through the mass of the iron. Indeed, it is otherwise known that the most rigid materials become flexible when fibrous or scaly crystals of different natures are distributed through them ; these latter may themselves form inflexible bodies when united to larger masses. The flexible Indian sandstone, for instance, consists of a mass of quartz crystals through which fibres of asbestos are uniformly disseminated; other kinds of flexible sandstones contain mica crystals in the quartz mass, as, for instance, the itacolumite, which, in Brazil, is regularly associated with the diamond. The flexibility of the respective bodies must in all these cases be ascribed to the property of the smooth crystals to change their relative position to each other, and with regard to the mica scales in the sandstone, they behave like the graphite scales in the iron.

According to Pelouze and Fremy the specific gravity of malleable iron approaches very nearly that of cast-iron. Brull, as the result of three determinations, found the numbers 7.10, 7.25, and 6.35. The specific gravity of wrought iron being from 7.6 to 7.8, we have another proof that malleable cast-iron is not identical with wrought iron. The fracture of malleable cast-iron is very different from that of any kind of wrought iron; it is darker and less brilliant, and lacks that fibrous aspect so characteristic of tough wrought iron. It is similar to dark and ordinary pottery, but different from it in color and lustre. In forging, the aspect of the fracture becomes greatly altered, on account of the flexibility of the material, which sometimes requires considerable hammering before it breaks. The fracture of very carefully manufactured malleable iron appears, on the average, more like that of a very fine grained, white cast-iron than that of wrought iron. In large pieces the fracture is uniform throughout. In filing, turning, and planing it works quite similar to wrought iron, but the surface often appears somewhat whiter. Large pieces can seldom be well turned to a great depth. According to some statements, malleable iron is capable of taking a better polish than cast-iron, and it takes as good a one as cast steel. It also holds a better lustre than many sorts of dark and impure wrought iron, but the polish is inferior to that of good steel, as in razors of first quality, even the surface appears a little whiter. Good hard cast-iron may probably be polished as well. With regard to the hardness, reliable data are not procurable. Malleable cast-iron is generally very soft—softer than wrought iron of any kind. It takes the impression of the hammer with a very slight blow, and wears off rapidly in contact with rough surfaces.

It is exceedingly porous, as may be expected from its small density. According to Brull, oil, when left in a cup of malleable iron, penetrates through it in a very short time; the correctness of this assertion, however, remains doubtful. Cast-iron bells are far more elastic than bells of malleable iron, producing also a higher and clearer sound.

Morin and Tresca have found that the elasticity of malleable cast-iron is considerably less than that of the most inferior wrought iron. The absolute power of resistance is indicated by the latter as being 35 kilogrammes per square metre. Thin pieces, of a diameter not over one-quarter or three-eighths of an inch, may be bent while cold, without cracking; but they can rarely be restored to their original state without being partly or altogether fractured. However, the end of a rod may be forged till red hot, without a break or crack being produced ; thin plates may safely be hammered into hollows, provided they are not too deep. Malleable iron will bear rolling to a small degree. All these manipulations bring about a closer grain, and a fracture similar to that of fine grained steel-like iron. No instance is known where malleable iron has been drawn into wire; but this is possible, since it will bear a slight elongation, assuming thereby a finer grain. It may be pretty well forged at a low red heat, somewhat above a cherry red heat, but in endeavor-

ing to beat it out, it tears and breaks to pieces. According to Mallet, this temperature, and that beneath a bright yellow heat, are those at which it may be best forged; but it is more than probable that various kinds act differently under the same circumstances. This peculiarity certainly deserves further attention, on account of the fact that various articles which have not, as yet, been produced from malleable iron, might advantageously be made from it in cases where the form of the cast piece might have to be altered afterward. When hammered at yellow heat, malleable iron falls to pieces, and large, not uniformly cemented pieces, appear in the interior.

It is clear that malleable iron can not be welded properly; indeed, this is the case even if two pieces can be made to stick together, and the surface of contact be kept free from rust; it is self-evident that it can not be welded with wrought iron or steel, still it may be soldered with them by means of a hard solder. With respect to the fusing point of this metal, it is a high one; it lies above that of gray or halved cast-iron, but probably not above that of many sorts of white or hard cast-iron, and certainly considerably below that of cast steel. In the fire, malleable cast-iron is said to become more slowly oxidized than ordinary cast-iron. In France, the silver refiners use a large number of crucibles that are manufactured from that material, but no accounts exist of how much iron they leave to the silver. According to Brull, malleable iron can be tempered with the ordinary carboniferous cementing powders, as well as with prussiate of potassa. If watered when bright red hot, it may be tempered more or less; still the temper is always imperfect, not uniform, and quite different from that of good steel, but perhaps more perfect than that which wrought iron assumes, when suddenly cooled. Still, correct statements are yet wanting with regard to this point.

NOTES ON THE GREAT PYRAMID OF EGYPT.

From a recent pamphlet* by Col. Sir Henry James, of the British Ordnance Survey, we extract the following notes:

Herodotus, writing about the year 450 B. C., tells us that the Egyptian cubit is equal to that of Samos, that is to the Greek cubit.

In the Hecatompedon of the Parthenon at Athens (so called because the platform on which the columns stand was made a double square of exactly 100 ft.) we have preserved the length of 100 Greek feet at the time this temple was built, about 440 B. C.

From the measurements made by Mr. Penrove at the Parthenon in 1846, we have the length of the Greek cubit equal to 18.2405 in., and if the assertion of Herodotus be correct, this must have been also the length of the Egyptian cubit at the time he wrote, about 2,320 years ago.

We shall presently see that this was also the precise length of the Egyptian cubit at the time the Great Pyramid was built, about 4,000 years ago.

Sir Isaac Newton, in his celebrated "Dissertation on Cubits," says: "It is very probable that at first the measure of it (the Great Pyramid) was determined by some round number of Egyptian cubits."

From a measurement by Mr. Inglis, who first measured all four sides of the base, a mean length was obtained of 9,110 in.

The length similarly obtained by the Ordnance Surveyors was 9,130 in. A mean of the two results is 9,120 in., and it is remarkable that one of the measures of Mr. Inglis is exactly 9,120 in., and of one of the Ordnance Surveyors 9,121 in.

We may, therefore, regard 9,120 in., or 760 ft., as the true length of the side of the Pyramid. But this is precisely 500 Egyptian or Greek cubits of 18.2405 in.

This verifies the conjecture of Sir Isaac Newton that the base was made a round number of Egyptian cubits.

King Cheops, having decided that the base of his Pyramid should be 500 cubits square, decided also that the rise at its corners should be 9 in height to 10 in horizontal length.

The length of the side of the square base being 760 ft., half of the diagonal is equal to 537.4 ft., nine-tenths of which is the

* Notes on the Great Pyramid and the cubits used in its design. By Col. Sir Henry James, Director-General of the Ordnance Survey. Southampton: Thomas Gutch & Co., 1869.

height, 483.66 feet; which agrees very closely with several previous determinations.

The angle of the corner, therefore, was about 41 deg. 59 min., which corresponds very closely with measurement. The angle of the slope of side would accordingly be 51 deg. 51 min. Col. Vyse, from actual measurement of the casing stones, found the angle to be between 51 deg. 50 min. and 51 deg. 52 min.

A square pyramid having a rise of 9 in 10 at its angles, has also this remarkable proportion : its height is to the periphery of its base as the radius to the circumference of a circle, very nearly.

In his "Dissertation on Cubits," Sir Isaac Newton says: "In the middle of the Pyramid was a chamber most exquisitely formed of polished marble, containing a monument of the king. The length of this chamber, according to the measure of Greaves, was 34,38 ft., the breadth 17.19 ft.; that is, it was 20 cubits long and 10 cubits broad, the cubit being supposed to be 1.719 English ft."

The cubit thus derived was, therefore, 20.628 in. in length, and called by Newton the cubit of Memphis.

He goes on to say: "Those who shall hereafter examine the Pyramid, by measuring and comparing together with greater accuracy mere dimensions of the stones in it, will be able to determine with great exactness the true measure of the cubit of Memphis, and from thence the sacred cubit."

The cubit of Karnak, in the British Museum, measured carefully by the author, was found to be 41.398 inches in length. It is divided into 14 palms, and the palms into 4 digits. This is, therefore, a double or royal cubit of Memphis, the single cubit being 20.699 in. in length, and differing only .071 in. from that deduced by Newton from the measure of the King's chamber.

Again, Newton says in his "Dissertation on Cubits:" "I am inclined to think that the cubit of Memphis, at the time when the Jews went down into Egypt, was equal to 5 palms of the Chaldæo-Hebraic cubit, and that the Jews thus determined the magnitude of that cubit by 5 palms of the proper cubit."

This would make the Chaldæo-Hebraic cubit one-fifth longer than the cubit of Memphis, or equal to 20.699 + 4.14 = 24.84 inches.

A cubit found by Mersennus measured 24.83 inches, and this is the length of the sacred Hebrew cubit given by Newton as the final result of his investigations.

This was probably divided into 6 palms of 4.14 in. each, and 10 of them making the royal cubit of Memphis.

This cubit is the breadth of the entrance passage to the Pyramid, and the King's chamber is 10 such cubits in length by 5 in breadth.

The cubits upon the Nilometers at Cairo and at Elephantine are equal to the cubit of Memphis, but are divided into 6 palms.

The cubit length of 20.699 inches was divided in three different ways.

On the sacred cubit it was divided into 5 palms; on the Nilometer into 6 palms, and on the cubit of Memphis into 7 palms.

The angles of inclination of the descending entrance passage to the Pyramid, and of the ascending passage to the King's chamber, are the same, and skilfully designed by the architect to be a little under the "angle of rest or quiescence," or a little over 26 deg.

At this angle anything could be made to slide down with ease.

The adjustment of the two slopes admits of the use of counterpoised trucks, by means of which any one could be easily transported from the entrance of the Pyramid to the grand gallery within.

The Line to Salt Lake City.—On the 10th January, the completion of the line which connects Salt Lake City with the Pacific Railroad, and thus brings the capital of Mormondom into railway communication with all the great cities of the Union, was celebrated at Salt Lake. The line is 37 miles in length, its northern terminus being at Ogden, the junction of the Union Pacific and Central Pacific roads, and it is unique in the history of railways in this, that it has been built from first to last without money. The iron and rolling stock were supplied by the Union and Pacific Company in payment for work done in the construction of that line; the contracts for the making of the road were taken in return for shares in its stock. Fifteen thousand Mormons, it is estimated, attended the celebration of the completion of the line.

RUSSIAN ORDNANCE EXPERIMENTS.

From "Engineering."

We print the following particulars, translated from the "Russian Artillery Journal," of the trial of an 11 in. Krupp's cast-steel breech-loading gun, fired against the Hercules' shield last August, at the Wolkow Artillery Ground, near St. Petersburg.

Up to the year 1868, the regulation calibres of our breech-loading guns for coast defence were 8 in. and 9 in.

Trials made in Russia, and the comparative trial with guns of large calibre in Prussia, agreed in demonstrating that the 8 in. coast gun acts with great effect on ships with 4½ in. armor plating, even at distances of 1,866 yards, and that at the same distance the 9 in. gun can do very serious damage to ships with 6 in. armor plating. At a distance of 700 yards the 9 in. gun pierces an armored shield with 8 in. plates. For success in attacking ships with 8 in. or 9 in. plates at great distances, or ships with still thicker plates even at short distances, the 9 in. gun is not of sufficient power. Having regard to this, we have included the 11 in. gun in the regulation calibres for coast defence.

The first trial gun of this calibre, made of cast-steel and strengthened with hoops, was manufactured for our Government at Krupp's factory. This gun differed somewhat in its measurements from the design to which the new 11 in. guns are made. This difference, which arose from the gun having been originally intended for a muzzle-loader, consisted principally in the length of the bore, being 27 in. shorter than the length of the bore of the 11 in. gun, according to the design finally adopted. In consequence of this, the initial velocity of projectiles fired with battering charges from the trial gun would necessarily be about 50 ft. less than from the new guns. The trial gun had been submitted last year at Krupp's factory to a trial of endurance, had fired 400 rounds with battering charges, and had then been removed to the Wolkow Artillery Ground, near St. Petersburg, to ascertain its destructive effect against armored shields of very great strength.

The experimental firing took place in the month of August of the current year, against a shield representing a portion of the broadside of the iron-clad English ship Hercules. This shield was built up in the following manner: Three wrought-iron plates, each 16 ft. long, 3 ft. 8 in. broad, the two lower 9 in., the upper one 6 in. thick, were fastened by bolts with countersunk heads to a backing consisting of horizontal teak balks, 12 in. thick, between which, through their whole thickness, seven 1 in. strips of iron plate were inserted, strengthened with angle iron.

Immediately behind the teak balks were two wrought-iron plates, one behind the other, each 1 in. thick. Behind these came a row of vertical oak balks, 9 in. thick, between which, through their whole breadth, were inserted nine 1 in. strips of iron plate, strengthened with angle iron. The whole rested against two rows of horizontal oak balks, the front row being 6 in. thick, and the hinder 9 in. Behind the latter was fastened a 1 in. wrought-iron plate. The whole thickness of the backing was, therefore, 39 in.; the whole thickness of the part of the shield with 9 in. plate, 48 in., and the whole thickness of the part of the shield with 6 in. plate, 45 in. The whole length of the shield was 16 ft., its height 11 ft. At the back of the shield five wrought-iron 1 in. stays were riveted on, and rested on 14 in. timbers, which were connected together, and formed a frame to support the shield. All three plates were made at the Millwall Works, London. The Hercules shield is one of the very strongest armored shields designed up to the present time.

In June and December, 1865, at Shoeburyness, gunnery experiments with the Armstrong 300-pounder (10.5 in.), and 600-pounder (12 in. and 13 in.) were made against a similar shield. The solid steel projectiles, fired from the 300-pounder, with 50 lbs., 60 lbs., and 66 lbs. of powder, did not pierce the shield, even at the shortest distances. The 600 lbs. solid steel projectiles, fired with a charge of 100 lbs., at a distance of 700 yards with an initial velocity of 1,420* ft. per second, went through the plate, and remained in

* This statement cannot be correct. The English report gives 1,276.27 ft. for a final velocity for a steel shot weighing 600 lbs. The velocity, 1,420 ft., was at 60 ft. from muzzle of gun.

the wood backing when they struck undamaged portions of the shield; on the other hand, when they struck places in the shield which were already weakened by previous rounds, they went right through the target. From the results of the trials at Shoeburyness, it appeared that the Hercules' shield is of very great resisting power, and that the capabilities of the 600-pounder Armstrong gun against it, even at small distances, were insufficient.

The firing performed here from the 11 in. cast-steel breech-loading gun, took place at a distance of 466.6 yards, with cast-steel shells, with *thin* lead jackets, which were made at Krupp's works, and brought up to the weight of 550 lbs. by filling the hollow with sand and filings. Five rounds were fired from the gun, one with battering charge, *i. e.*, with 91.5 lbs. of prismatic powder, and four with diminished charges, for the purpose of determining their destructive effect upon the target at different distances, without rendering it necessary to move the heavy gun to other distances. To this end two rounds were fired with a charge of 85.5 lbs. of prismatic powder, and two rounds with 72 lbs. of the same powder. With the charge of 85.5 lbs., the trial gun produces the same effect at 466.6 yards as with the battering charge at 746.6 yards, and as the new 11-in. gun with battering charges at a distance of 1,108.3 yards. With a 72-lbs. charge the effect of the trial gun is the same at 466 yards as at a distance of 1,610 yards with the battering charge, and the same as that of the new 11-in. gun at a distance of 1,960 yards. The effect of the 11-in. trial gun with battering charge at 466.6 yards is the same as that of the new 11-in. gun at 842 yards.

The principal damage done to the shield during this gunnery trial was as follows: The first shot fired with a battering charge of 91.5 lbs. of prismatic powder struck the lower 9-in. plate in about the middle of it, near the upper edge, went through the whole target and continued its flight into the plain. The hole produced in the plate was of an oval form, having a horizontal diameter of 11 in., and a vertical diameter of 13 in. By this shot a bolt was broken, carrying away a stay from the backing. The projectile, which was picked up after the firing, proved to be quite whole; the lead jacket was stripped off; the length of the shot was lessened by $\frac{1}{8}$ in.; but in other respects its dimensions had apparently remained unaltered. At the second round, which was fired with a charge of 85.5 lbs. prismatic powder, the projectile did not strike the shield direct, but grazed 16.3 ft. before it, hitting a plate lying on the ground, and then struck with its side against the lower 9-in. plate of the shield. The indentation produced was about $2\frac{1}{2}$ ft. long, up to 1 ft. broad, and up to $4\frac{1}{2}$ in. deep. The plate was buckled inwards 2 in., and showed cracks on the bottom edge of the hole made by the first shot. The projectile broke in pieces.

At the third round, which was fired with 85.5 lbs. of prismatic powder, the projectile struck the joint between the two lower plates, pierced the whole shield, grazing 58 ft. 3 in. behind, and then continued its flight. The dimensions of the hole made by this shot were almost the same as in the case of the first. By this shot a bolt was also broken and a stay carried away; the shot, which was picked up after the trial, proved to be broken into two equal parts, about perpendicular to its axis.

At the fourth round, which was fired with a charge of 72 lbs. prismatic powder, the shot struck the upper 6-in. plate near the lower edge, grazing the top edge of the middle plate, and went right through the shield. The oval hole made by this shot was of somewhat larger dimensions than the previous ones, the horizontal diameter being about 13.5 in., and the vertical 11.9 in.

Of broken bolts there were 3—2 in the top plate and 1 in the middle plate; in addition, a stay was separated from the backing. The shot, which was picked up after the firing, proved to be quite whole; the lead jacket was stripped off; its length was diminished by almost $\frac{3}{10}$ in., otherwise its dimensions had apparently remained unchanged.

At the 5th round, which was fired with a charge of 72 lbs. prismatic powder, the shot struck the middle 9-in. plate near the lower edge, penetrated so far into the target that the surface of the end of the shot was level with the front surface of the plate, and there remained. In doing this the head of the shot went through the plate the whole thickness of the teak backing, the two 1 in. plates, behind the teak timbers, and about 4 in. into the upright oak balks. The other damage visible

after this shot consisted in injury to the stay, which was in the neighborhood of the point of impact, and in carrying away some rivets. The shot remained apparently whole.

Ater the termination of the trial, the whole shield had been driven back 6 in., almost parallel to its original position.

This gunnery trial, in which the plates of the shield had proved to be very good, showed that our 11 in. gun of the new construction, when fired with good steel projectiles with a thin lead jacket, is capable of doing the following damage to armor-plated walls of the strength of the broadside of the British ship Hercules.

1. At a distance of about 842 yards this shield, both with 6 in. and 9 in. plates of good quality, is pierced with a considerable surplus of power.

2. At a distance of about 1,166 yards this shield is also pierced, although with but a small surplus of power.

3. At a distance of about 1,983 yards a shield of the strength described, with 6 in. plates, is pierced.

4. At the same distance, when fired against the shield protected by 9 in. plates, the shot pierces the plate, and sticks fast in the backing, after it has penetrated its whole length. From the results of this xperiment, it may be concluded that our 1 in. rifled *cast-steel* breech-loading gun of the new make, provided with good *steel* projectiles, is considerably superior in execution to the English 12 and 13 in. (600-pounder) wrought-iron rifled 25-ton muzzle-loading guns; and that it is a very efficient gun against fleets with armor plating of considerable thickness, not only at short and medium, but even at greater distances.

If we consider that, as shown by the experiment made, when fired against the Hercules' shield, at a distance of about 1,983 yards, the projectiles of the 11 in. gun penetrate their whole length, and, at a shorter distance of about 1,166 yards, go through the whole shield, and avail ourselves of the formulas derived from the results of the gunnery experiments of the English, Prussian, and other artilleries, against armor plates with backing, we gather that the distance of 1,399 may be regarded as the limit at which our 11 in. guns, of new make, may produce very destructive effects when fired against ships whose broadsides are of the strength of the Hercules and are covered with 9 in. plates.

Although at this distance we cannot reckon upon every shot fired piercing the broadside described, still it is beyond a doubt that they would stick fast in the wood backing, after having gone through the 9 in. plate, and there produce the full effect of their bursting charge.

At a distance of about 1,282 yards all good 11 in. steel projectiles must pierce a shield of the strength of the Hercules' broadside, protected by wrought-iron plates of the best quality."

THE RESISTANCE OF VESSELS.

(*Continued from page 288.*)

ROLLING OF SHIPS.

Stability and Free Oscillation.

The statical stability of a ship in still water depends upon two equations and an inequality.

Its weight must equal that of the fluid it displaces, or it will adjust itself by changing its water-line. This involves a first equation.

The centre of gravity of the displaced water must be in the same vertical line with the centre of weights, or there will be a couple which will produce rotation; after which the ship will take up a fresh position. This involves a second equation.

In case of a small angular displacement, the centre of gravity of the displaced water (or centre of buoyancy) must move out faster than the centre of weights; otherwise, on the slightest derangement, there will be an upsetting couple; that is to say, the equilibrium is unstable. This involves an inequality.

The arm of the couple is the horizontal distance between the centres of weight and buoyancy. The moment of the couple is the product of this into the weight, or, what is the same thing, the displacement of the ship. If the centre of buoyancy moves out faster than the centre of weight as the ship heels, there is a right-

ing couple; if not, there is an upsetting couple, which tends to bring the ship to some new position of equilibrium.

If we consider a vessel having a plane of symmetry, like that in which the masts, stern, stern-post, and keel of ordinary ships lie, and rolling transversely, we gain much in geometrical simplicity, and also in simplicity of language. We are enabled to deal with the mechanical questions by means of plane geometry, and we are still able to extend them when necessary, by the ordinary rules of the composition of motion. For this purpose, we have only to consider the axis of motion as parallel to the plane of symmetry and to the water section. The statical stability, as already remarked, is measured by the weight and by the horizontal distance between the centres of weight and buoyancy. But when these coincide in horizontal position, as they do when there is equilibrium, we are driven to some other measure in order to avoid indeterminateness at the limit. For this purpose we avail ourselves of the point at which the vertical line through the centre of buoyancy strikes the plane of symmetry, or *middle line plane*, as it is technically called. The limiting position of this intersection, when the angular deviation is indefinitely small, is called the metacentre. This metacentre is the critical point below which, if the centre of weight be kept, there will be stable equilibrium.

It is shown in books on hydrostatics that if a floating body receive a *small* inclination, the two water sections intersect in a line passing through the centre of gravity of each, and also that the line, passing through two successive centres of buoyancy, tends to parallelism with the water section. It follows that the stability of a ship, statically considered, may be measured by the statical stability of a solid whose centre of gravity coincides with that of the ship, but whose surface, instead of floating in water, rests on a horizontal table. This representative surface is the surface formed by the centres of buoyancy of the ship at different inclinations. The metacentre of the ship is then the centre of greatest or of least curvature of this representative surface, called the *surface of buoyancy*, according to whether we consider transverse rolling or longitudinal pitching.

When we pass from statics to dynamics, the righting or upsetting force simply represents an acceleration. But if the ship be considered as concentrated at its centre of gravity (in disregard of the actual distribution of weights in respect of inertia), the same geometrical considerations hold, and the space through which the centre of gravity rises or falls, as the surface of buoyancy rolls, is called the measure of *dynamical stability*.* It is simply proportional to the integral of the statical stability taken with reference to the angle of inclination. Its product into the displacement gives the *mechanical work* required to heel the ship, considered as concentrated at its centre of gravity, to a given angle. An example of its use is in the solution of the problem of finding how much a ship would lie over to a sudden gust, strong enough, if it came on gradually, to heel the ship to a given angle. The rough solution is, that she would lie over to double the angle of the statical stability, and this remark is of importance in judging of the safe limits of a ship's stability. This solution, it is to be observed, takes no account of the moment of inertia of the ship about its centre of gravity, and very little account of external form.

Experiment and theory both go to prove that the time in which a ship performs a complete double oscillation varies very little, whether the amplitude of the oscillation be small or large. Hence every ship has its equivalent pendulum. If k be the radius of gyration of the ship, μ the distance between the metacentre and the centre of gravity, the length of the equivalent pendulum is $\frac{k^2}{\mu}$; the periodic time† is $2\frac{\pi k}{\sqrt{g\mu}}$, and the greatest angular velocity is $\frac{2\sqrt{g\mu}}{k}\sin\frac{1}{2}\theta$, where θ is the amplitude, or departure from the vertical; but the approximation in this last formula is much less than in that for the time.

Dupin has shown that the free rolling of a ship, regarded without reference to

* The true dynamical stability is the actual work done in heeling. But the words are ordinarily used in the sense stated in the text.

† The time here used is that of a double oscillation; *i.e*, the time which elapses between the bob of the pendulum passing the lowest point twice in the same direction. There is very often confusion between double and single oscillations, both with analysts and in the records of experiments.

the disturbance or resistance of the water, is analogous to the free rolling and sliding on a smooth plane of the surface, which is the envelope of its planes of flotation; the centre of gravity, the upward pressure of the fluid, and the moment of inertia being supposed to remain unaltered. But, although this statement reads simply enough, the expression for the time and the period, which result from it, are exceedingly complex. An investigation of it, subject to the sole restriction that the transverse section of the surface enveloping the planes of flotation shall be circular, has been given by Canon Moseley, in the "Philosophical Transactions" for 1850, p. 626, and is reprinted in his "Engineering and Architecture." The resulting expression depends upon a hyper-elliptic integral. But we are without evidence as to how far the restriction is fulfilled by ordinary ships; and we do not find reason for supposing that the variation of the radius of curvature, which is thus taken as constant, has ever been practically investigated. There is, however, no difficulty in extending the formula to the general case; but it does not appear that the integration can be effected without introducing restrictions. At any rate the value of the integral has not yet been traced, except for small oscillations, when it reduces to the one previously given. There is a reduction in some particular cases,* and notably in the case of isochronous ships. Professor Rankine* has shown that the condition of isochronism is, that the curve of buoyancy should be the second involute of a circle described about the centre of gravity.

It does not appear that the arithmetical consequences of the variation of the law connecting time and angular velocity in unresisted free rolling have ever been worked out. It would be a very laborious business, and we shall see by and by that it is not the chief problem.

Reverting to the approximate formulæ for small oscillations,

$$\text{periodic time} = 2\frac{\pi k}{\sqrt{g\mu}} = 2t, \text{ suppose;}$$

$$\text{greatest angular velocity} = 2\frac{\sqrt{g\mu}}{k}\sin\tfrac{1}{2}\theta,$$

$$= \frac{2\pi}{t}\sin\tfrac{1}{2}\theta,$$

we see that the periodic time of the oscillation varies directly as the radius of gyration, and inversely as the square root of the metacentre height. This teaches us how to regulate the periodic time of a ship, either in settling her design, or in the distribution of her weights. We see, for instance, that a vessel with a rising floor and flaring sides tends to quick rolling, by having a high metacentre; that a cargo of railway bars has the same effect, by bringing down the centre of gravity; and that running in the guns and sending down the masts has a similar tendency, by decreasing the radius of gyration. The expression for the greatest angular velocity has been sometimes interpreted as indicating that quick rollers roll through

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* Let k be the radius of gyration, λ the height of the metacentre above the centre of buoyancy, H_1 and H_2 the *depths* of the centres of gravity and buoyancy, all taken for the upright position. Also let θ be the inclination, and ϑ_1 the extreme, and ρ the *height* of the centre of curvature *above* the actual plane of flotation. The Canon Moseley's formula gives for the periodic time of the double oscillation:

$$\sqrt{\frac{2}{g}}\int_{-\theta_1}^{+\theta_1} d\theta \times \sqrt{\frac{k^2+(H_1+\rho)^2\sin^2\theta}{\{H_1-H_2+\frac{1}{2}\lambda(\cos\theta+\cos\theta_1)\}(\cos\theta-\cos\theta_1)}}$$

It will be observed that $(H_1+\rho)\sin\vartheta$ is nothing but the horizontal distance between the centre of gravity of the ship and that of the plane of flotation; or, in other words, the perpendicular from the centre of gravity on the normal to the flotation envelope. It seems, at the same time, simpler and more general to use this (which we may call ν), instead of considering the curvature. We thus get the periodic time,

$$\sqrt{\frac{2}{g}}\int_{-\theta_1}^{+\theta_1} d\theta \times \sqrt{\frac{k^2+\nu^2}{\{H_1-H_2+\frac{1}{2}\lambda(\cos\theta+\cos\theta_1)\}\{\cos\theta-\cos\theta_1\}}}$$

Now, if ν be constant, that is to say, if the flotation envelope be the involute of a circle described round the centre of gravity of the ship, this reduces to a complete elliptic integral of the first kind; but the solution is not mechanical unless $\nu=0$ or the flotation envelope reduces to a point. When, moreover, the centres of gravity and buoyancy coincide, H_1-H^2 vanishes, and the integral may be at once transformed to its regular expression by writing $\sin\vartheta=\sin\vartheta_1\sin\phi$. We then get for the periodic time,

$$4\frac{\sqrt{k^2+\nu^2}}{\sqrt{\lambda g}}\int_0^{\frac{1}{2}\pi}\frac{d\phi}{\sqrt{1-\sin^2\theta_1\sin^2\phi}}$$

The time at any moment is got by integrating from $-\vartheta_1$ to any value of ϑ instead of to $+\vartheta_1$.—C. W. M.

* See "Transactions of the Institution of Naval Architects," vol. v., for 1864, p, 34. See, also, Froude, "On Isochronism of Oscillation of Ships," vol. iv., for 1863, p. 218.

large angles. The fact appears to be experimentally true, but its inference from this formula involves reasoning in a circle. The formula only shows that for the same amplitude the greatest angular velocity varies inversely as the time; but this tells us nothing about the amplitude, while the formula itself is obtained on the supposition that the amplitude is small.

The position of the ship's centre of gravity, and the length of the radius of gyration, cannot, practically, be obtained by calculation. The centre of gravity is generally found by shifting some known weights through known distances, and observing the angular motion. The displacement and metacentre are of course known by calculation, and the problem is then the same as if the ship were suspended from her metacentre.* The radius of gyration is found by observing the time of a small oscillation in still water, and then eliminating the effect of resistance.†

As the metacentre depends upon the moment of inertia of the plane of flotation, it is different for pitching from what it is for rolling, and so for any intermediate position.‡ Practically, the metacentre for rolling varies from 0 to 20 ft. (as an extreme limit) above the water line, while that for pitching is from 70 to 400 or more feet high. The moment of inertia of the ship also varies greatly with the direction of the axis about which it is taken.

FREE ROLLING IN A RESISTING MEDIUM.

The experiments of Messrs. Fincham and Rawson, undertaken at the suggestion of Canon Moseley§, led to the conclusion that, for vessels of semicircular section, in which the disturbance of the water is the least possible, the dynamical stability, found by experiment, differed very little from that derived from the rise and fall of the centre of gravity; but in the case of a model of triangular section, the stability found by experiment was in defect. In the semicircular model the extreme inclination produced by the sudden application of the force was, with a fair degree of approximation, double that due to its statical effect. With the triangular model the extreme was less than double the statical inclination. This is nothing more than might be expected from the disturbance of the water which would be set up by the angular model, and which would, of course, take up part of the work. But this experimental confirmation of theory is highly satisfactory; and, however we may now look back upon the matter, it is really upon these experiments that the confirmation of our theories rests.

In a resisting medium, the amplitude of the oscillations is very quickly effected, but the periodic time undergoes very slight change. But the period *is* altered to a slight extent. On this subject we refer, firstly, to the account given by Poisson, Stokes, and other writers on mechanics, concerning the oscillation of a pendulum in air; secondly, to Mr. Froude's experiments* on a pendulum oscillating in water, and thirdly, to Professor Rankine's Paper on Keel Resistance,† in which the measure of diminution is given on a certain hypothesis.

Bessel and Poisson have pointed out

* The method, with an account of some experimental determinations on several of H.M.'s ships, will be found in the "Transactions of the Institution of Naval Architects," vol. i., p. 38. See also vol. v., p. 1.; vol. vi., p. 1.; vol. vii., p. 205.

† As to this, see Mr. Rankine's note in the "Transactions of the Institution of Naval Architects," vol. v., pp. 31 and 32.

‡ See Dupin, "Applications de Géométrie." He shows that the metacentric heights for rolling and pitching are, in fact, only the two principal radii of curvature of the surface of centres of buoyancy, and hence the metacentres for intermediate positions may be found by the help of the ellipse of curvature.

§ See "Philosophical Transactions" for 1850, and Moseley's "Engineering and Architecture," pp. 616, 617.

* "Transactions of the Institution of Naval Architects," vol. iii. p. 31. Mr. Froude has there shown that when a pendulum or ship performs isochronous oscillations in a medium, the resistance of which varies as the square of the velocity, the amplitudes of the successive oscillations, as reduced by resistance, will form successive ordinates of a curve, which approaches, with a great degree of exactness, to an equilateral hyperbola, referred to one of its asymptotes; equal periods of the oscillations being represented by successive equal increments of the abscissa. The experiments with a pendulum as exhibited in the diagram (Plate 2, of the volume referred to), accord very closely with the law, which may be thus expressed: If θ_0 be the initial amplitude, and θ_m that at the end of the m^{th} oscillation, then that at the end of any other, say n^{th}, will be

$$\theta_n = \frac{m\,\theta_0\,\theta_m}{(m-n)\,\theta_m + n\,\theta_0}.$$

† "Transactions of the Institution of Naval Architects," vol. v., pp. 30, 31.

that the virtual loss of weight due to oscillation in a resisting medium is greater than that due to the mere immersion. Mr. Moseley makes the same remark with reference to the rolling of ships.

Professor Rankine has investigated the effect of the steadying action of a keel on the rolling in smooth water, on the assumption that the moment of the righting couple is simply proportional to the inclination, and also that the moment of resistance to rolling, caused by the action of the water on the keel and floor, is proportional to the angular velocity. He finds* that the periodic time is altered from

$$\frac{2\pi k}{\sqrt{g\mu}} \text{ to } \frac{2\pi k}{\sqrt{g\mu}\sqrt{1-\frac{gc^2}{4\mu k^2}}}$$

where c is a constant depending on the moment of the resistance, so that

$$c = \frac{\text{moment of resistance of water,}}{\text{displacement} \times \text{angular velocity}},$$

the effect of the resistance thus lengthening the periodic time in the same proportion as if the inertia of the rolling mass were increased in the ratio of unity to

$$1-\frac{gc^2}{4\mu k^2}$$

and periodic rolling in smooth water becoming impossible when $g c^2$ is equal to or greater than $4 \mu k^2$.

OF EASY AND UNEASY SHIPS.

There is much vagueness in the use of these terms. They are generally applied promiscuously to the practical hindrance caused by motion to the persons engaged in working or manœuvring the ship; to the inconvenience felt by passengers; to the straining of a ship's structure, or the tendency to shift her cargo, or to break away half-fastened weights, like boats or guns.

These all appear to depend in varying proportions on the following exact data:

The extent or amplitude of angular motion.

The rapidity of angular motion.

The acceleration of linear motion.

But the rapidity of linear motion, and the angular acceleration (except so far as this affects bending stress, or as it involves linear acceleration at a distance from the instantaneous axis) do not appear to have much practical influence.

In still water the only motion which is sufficiently great to cause inconvenience is that of rolling. Rolling sometimes produces, as secondary phenomena, both pitching and dipping; but neither of these is sufficient in extent, in still water, to produce inconvenience. The rolling, however, may be considerable, especially in the case of a ship going unsteadily, before the wind. But if the water itself be oscillating, even moderately, or if there be a gusty wind, then a synchronism between any two of the five movements—the wind, the waves, the rolling, the pitching, or the dipping,* or even (to a lesser extent) their concord at regular intervals, may cause them to enhance the effects one or another to such an extent as to become inconvenient, and in certain cases dangerous. In the case of a thoroughly uneasy ship in the most unfavorable circumstances, the axis of angular motion may assume any and every position, and the linear acceleration may take all conceivable directions; but although any particular point may describe the most irregular curves, both in form and speed, relatively to the vessel's course, yet the chief source of practical danger in open water depends upon the accumulation of motion arising from synchronism.

It appears to have been generally observed that vessels which have a short period of rolling, also roll through large angles. In this way the uneasiness of the rolling undergoes a double increase as the period diminishes. Further and more exact experiment is required, before we can say how far it is connected by synchronism with wave motion, or whether it is an independent phenomenon. Our present theories do not show it to be a necessary consequence of rolling in smooth water.

WAVES.

We do not consider it necessary to go into a formal discussion of this subject. As regards the behavior of ships, it is quite sufficient to assume that the profile of a simple wave is trochoidal, and that the particles of water move in circles in a vertical plane, at right angles to the

* "Transactions of the Institution of Naval Architects," vol. v., pp. 30, 31.

* Dipping is the name given to the vertical oscillation of the ship as a whole, relatively to the surface of the water.

ridges and valleys of the waves. The consequences of this motion are briefly as follows, on the assumption that the depth of water is unlimited.

The diameter of the circle, in which a surface particle moves, is the height of the wave from hollow to crest. Particles, which in still water would be at a lower level, describe smaller circles in the same period. A horizontal plane (in the still water) is thus converted into a wave-surface of the same period, but of reduced amplitude of oscillation.* The velocity of the particles (and on this depends the *impact* of a wave) is simply the circumference of one of these circles divided by the periodic time.

If we consider a column of particles which is vertical in still water, that column oscillates in wave-water like corn-stacks in a gust of wind, and it also oscillates vertically. But it always slopes *towards* the crest of the wave, and the obliquity thus induced goes to enhance that due to the wave-slope ; so that, if we regard the profile of a wave, a small portion of water, rectangular when still, undergoes a double deformation, the horizontal surfaces following the wave-slope, and the vertical surfaces being deflected towards the crest ; both causes tending to increase the angular deformation, instead of to preserve rectangularity.

The crest of the wave being sharper than the hollow, and the quantity of water invariable, the horizontal plane which lies half way between valley and crest is higher than the mean, or still water, level ; and its elevation has been shown to be equal to the height due to the velocity of revolution of the particles.

Considered as trochoids, the wave profiles are traced by a point within a circle rolling *under* a horizontal line. The line midway between valley and crest is the line of centres.

The particles of water above the line of centres are moving forwards, as regards the direction of advance of the wave ; those below that line backwards. The particles in the front face of the wave are rising, and those in the rear face falling.

The wave whose period is $\frac{1}{n}$th of a second, has a length of $\lambda = \frac{g}{2\pi n^2}$, whence we find the number of waves to a second to be $n = \sqrt{\frac{g}{2\pi\lambda}}$. The velocity of wave propagation, that is to say, of the apparent advance of the wave in a deep sea, is $n\lambda = \sqrt{\frac{g\lambda}{n\pi}} = \frac{g}{2\pi n}$.

In other words, the speed of the wave crest varies as the periodic time, and the length of the wave varies as their product, or as the square of either.

The vertical disturbance of a particle, whose depth in still water would be k, is

$$h^k = h\,\epsilon^{-\frac{2\pi k}{\lambda}}$$

h being the height of the surface wave.

No wave can be sharper than a cycloidal wave. For if the trochoid were looped, the particles in the loop would be unsupported. When the wave form tends to pass the cycloid, it must break.

The extreme observed height of ocean waves appears to be about 40 ft., and the greatest observed length 600 feet. ; these would have a periodic time of 11 seconds (roughly) ; their crest would advance at a rate of 33 knots an hour, and the velocity of the surface particles would be about 11.4 ft. per second. In short waves of the same height the particles of water move faster, in the inverse ratio of the period ; but the mass of moving water at the crest of the longer wave is the greater in the ratio of

$$\lambda - \pi h : \lambda^1 - \pi h,$$

where λ and λ^1 are the lengths, and h the height. If, therefore, the above mentioned wave were shortened to 200 ft. the surface particles would be moving at a rate of 20 ft. a second, while the mass of water in the crest would be about one-sixth. From such data it is easy to infer both the destructive effect of impact from the top of a wave, and the relative quantity of water which a ship would take on board in shipping a sea.

The front and rear of a trochoidal wave are exactly similar. Observation, as well as theory, shows that this is true to an extent not commonly believed for ordinary

* Drawings of the structure of a trochoidal wave will be found in the "British Association Reports" for 1844, plate 56 ; "Transactions of the Institution of Naval Architects," vol. i., for 1860, plate 7 ; vol. iii., for 1862, plate 3 ; vol. iv., for 1863, plate 10 ; vol. vi., for 1865, plate 10 ; "Shipbuilding : Theoretical and Practical" (Rankine), p. 69 ; Scott Russell : "Naval Architecture," plate 117.

waves. The exceptions are, when the wind is sufficient to push the tops of the waves at extra speed, and when the water shoals rapidly. But even here the relative steepness of the advancing face is exaggerated by most observers. Until a wave is about to break, the actual difference of slope remains very small.

It should be borne in mind that circular orbits and trochoidal wave-surfaces are only approximations, although near enough to the truth for purposes connected with the rolling of ships. In particular, it appears both from theory and observation that there is almost always some progressive motion combined with the orbital motion; and also that waves begin to break long before their crests attain a form so sharp as that of the cuspid cycloid; the two slopes at the crest of a breaking wave, cutting each other at right angles, or nearly so.*

The ordinary wave of a rough sea is usually an aggregate of waves of different period, and not unfrequently of different direction. For rough purposes, it is sufficient to draw each system of waves separately and add their corresponding ordinates, to get the resulting surface. This can hardly be relied upon in extreme cases; and, in any case, the motion of each particle is not according to any one or more wave systems separately; but it is a motion compounded of what would be due to each separately, if the others were not.

OSCILLATIONS OF A SHIP AMONG WAVES.

A treatise on "Shipbuilding, Theoretical and Practical,"† edited by Professor Rankine, contains in a very clear and condensed form, a *résumé* of nearly all that was known on this subject up to 1864, inclusive. The following abstract is chiefly taken from that work:

It is to be observed that what follows relates to the composition of the ship's oscillation with that of a simple trochoidal wave. The complete problem of a ship's behavior, depending as it does on wind, waves, rolling, pitching, dipping, yawing, variable head resistance, and lateral resistance, and direction of motion relatively both to wind and waves, is far too complicated even for statement, in an exact mathematical form.

If a ship floating passively in the water, and without any progressive motion, were wholly without stability, her centre of gravity, centre of buoyancy, and metacentre coinciding in one point, the motion assumed by that point would be exactly that of the centre of gravity of the mass of water displaced by the ship; that is to say, it would revolve once in each wave-period in a vertical circle of the same diameter with the orbits of the particles of water situated in the same layer.

This motion of the ship has received the name of *passive heaving*, that term being understood to comprehend the swaying from side to side, as well as the rising and sinking, of which the orbital motion is compounded.

Half the difference between the extent of heaving of the ship and the height of the waves is the extent to which, during the passage of the waves, her depth of immersion amidships is liable to be alternately increased above and diminished below her depth of immersion in smooth water. It appears that deep immersion and large horizontal dimensions, but especially deep immersion, tend to diminish the extent of the heaving motion of the ship as compared with that of the waves, and that the effect of those causes in producing this diminution is greatest among comparatively short waves.

The weight of the ship being combined with the centrifugal force due to her heaving motion, gives a resultant reaction through her centre of gravity, inclined to the vertical in a direction which, for passive heaving, is perpendicular to the wave-surface traversing the ship's centre of buoyancy (a surface which may be called the *effective wave-surface*); and that direction is the *apparent* direction of gravity on board the ship, as indicated by plumb-lines, pendulums, suspended barometers, lamps, spirit-levels, and the positions assumed by persons walking or standing on deck. The equal and opposite resulting pressure of the water, acting through the centre of buoyancy, is in like manner compounded of actions due to weight and centrifugal force; and it acts in a line normal to the effective wave-surface, that is to say, parallel to the resultant reaction of the ship. Those two forces balance each other, not when the ship's upright axis is vertical, but

* See "Philosophical Magazine," Nov., 1864.
† See pp. 72, 77, of that work.

when it is normal to the effective wave-surface; and when she deviates from that position, they form a righting couple tending to restore her to it. Thus the stability of a ship among waves, instead of tending to keep her steady, as in smooth water, tends to keep her *upright to the effective wave-surface;* and such is the motion of any vessel or other floating body having great stability and small inertia, such as a light raft. This may be called *passive rolling*, or *rolling with the waves.*

Passive rolling is modified by the inertia of the ship, which makes her tend to perform oscillations in the same periodic time as in still water, by the impulse and resistance of the particles of water against her keel and the sharp parts of her hull, which tend, under certain circumstances, to make her roll against the waves, that is, inclining towards the nearest wave-crest, and by other circumstances.

The tendency to keep upright to the effective wave-surface may be distinguished from the tendency to keep truly upright, by calling the former *stiffness* and the latter *steadiness.* In smooth water, stiffness and steadiness are the same thing; amongst waves they are different, and to a certain extent opposed; that is to say, the means used for obtaining one of those qualities are sometimes prejudicial to the other. Stiffness is favorable to the dryness of the ship, and to the power of carrying sail; steadiness is favorable to her strength and durability, and the safety of her lading, and in ships of war to the power of working guns in rough weather.

A ship, whose course is either oblique or transverse to the wave-crests, is made by the waves to perform a series of longitudinal oscillations, which may be called *passive pitching and scending.*

In all the oscillatory movements which a ship performs among waves, two series of oscillations are combined—those in which the ship keeps time with the waves, being her passive or forced oscillations, and those which she performs in periods depending on her own mass and figure, as in smooth water, being what may be called her free oscillations. The tendency and ultimate effect of the resistance of the water is to destroy the free oscillations after a certain time, so that the forced oscillations alone are permanent.

Passive heaving, or the motion of a ship when each of her particles performs an orbital motion, similar and equal to that of a certain particle of the water in which she floats, takes place when the ship floats amongst waves without having progressive motion.

The progression of the ship when under way alters the action of the waves upon her in various ways, which depend mainly upon the *apparent period* of the waves relatively to the ship—that is, the interval of time between the arrival of two successive crests at the ship, and upon the *apparent slope* of the effective wave-surface in a direction athwart the ship, the latter circumstance being connected mainly with forced rolling oscillations.

When the apparent periodic time of the waves is modified by the progressive motion of the ship, the time during which the forces act, which produce the heaving motion of the ship, is altered in the ratio of the apparent period to the true period; and the extent of the heaving motion is also altered in a proportion which, for moderate deviations of the apparent from the true period, varies nearly as the square of that ratio. This law, however, does not continue to hold for a very great increase of the apparent period, the extent of heaving being less than the ratio first mentioned.

Hence, the heaving motion of a ship is more extensive than that of the effective wave-surface, when the angle made by her course with the direction of advance of the waves is acute; and less extensive when that angle is obtuse.

Yawing, or swerving of the vessel from side to side by oscillation about an upright axis, is, when produced by the waves, the effect of the lateral swaying which forms the horizontal component of the heaving motion, taking place with different velocities, or in opposite directions, at the bow and stern of the vessel. The forces producing it are greatest when her course lies diagonally with respect to the direction of advance of the waves.

For reasons already stated a very light and stiff ship tends to float like a raft rolling *with the waves,* and assuming at every instant the same slope with the effective wave-surface.

Let a board, having very little inertia, and no stability, be placed so as to float upright in smooth water; then, when the

water is agitated by waves, that board will accompany the motions of the originally upright columns of water; that is to say, it will roll *against the waves*, inclining at every instant in a direction contrary to the slope of the effective wave-surface.

(TO BE CONTINUED.)

THE RENEWAL OF THE KING'S CROSS STATION ROOF.

From "The Engineer."

The following is an abstract of a paper read by Mr. R. M. Bancroft before the Civil and Mechanical Engineers' Society, at a meeting held on the 8th of December, 1869.

The Great Northern passenger terminal station at King's Cross was opened to public traffic in 1852, and its roof constructed during the two previous years, and was at the time a work which created some little sensation, as it was the largest span roof of the laminated type constructed in this country.

From designs of French roofs it appears that Colonel Emy, of the French Military Engineers, was the first person to draw public attention to the subject, by applying the system of the laminated timber arches in the construction of the roofs over the Riding Schools of Marac, near Bayonne, 65½ ft. span, and Libourne, 69 ft. span, about the year 1819. They were both semicircular, and made to form a complete truss to support the covering, by means of principal rafters tangential to the curves, and tied to the semicircular rib by a number of radiating clipping braces. The ribs were bent complete without treenails, and were maintained in their form by iron stirrups subsequently placed, and passing round the whole system at intervals, and by bolts going through the laminations in the intermediate spaces.

Mr. John Green, in the year 1827, made a design and model for a bridge, with timber arches resting upon stone piers. In 1833 the plan was adopted, and in 1837 it was put into execution at the Ouse Burn Viaduct of the Newcastle and North Shields branch of the North-Eastern Railway.

The late Joseph Locke, Esq., C.E., constructed a bridge upon the laminated arch principle for the Rouen and Havre Railway over the Seine and Epaulet, near Rouen. The arched ribs of this bridge were made 4 ft. deep by 1 ft. 6 in. wide, and formed by bending 16 planks 3 in. thick of Baltic timber, placed concentrically over each other, each course being fastened to those above and below it by oak treenails. These treenails were made to pass through two courses of planks into the third. The ribs were bent upon a platform on the ground to half the thickness of the ribs, thus dispensing with the necessity of centring, and were thus placed in position by a travelling crane, and the remaining depth of the rib was completed in place.

In bridges built upon this plan it was found, every time the girders or ribs deflected under moving loads, the concentric layers of planks detached themselves slightly from the layers that were respectively above and below them, so that a passage was formed for the admittance of aqueous vapors to the inside of the ribs, where a process of fermentation or "wet rot" rapidly developed itself. The King's Cross passenger station was erected on the site of the Small-pox Hospital in 1851–2, and therefore the roof has stood about eighteen years—a period much longer than the bridges built on the same plan. The principals of this roof were constructed upon a platform on the ground, to which chocks were secured at intervals of 4 ft. to 5 ft.; these were set out to a radius corresponding with the innermost layers of the planks, and were secured by means of clamps to the chocks. On this first layer a second series was laid and fastened with 3 in. wood-screws, 8 in. apart, and again clamped to the chocks, and so on until the whole thickness of the rib was completed, care being taken that all the planks broke joint.

The ribs were hoisted to place by three derricks, one placed against each wall, and a third in the middle of the span. A band of wrought iron, 4 in. by ½in., was finally placed round the topmost plank, and bolts passed through both iron and wood about 2 ft. from each other in the

centre of the rib. These laminated ribs in their turn support whole timber purlins, which carry the covering. As to the cause of decay in this roof, in the large quantity of timber used most likely some of it was in a sappy or wet state. The planks being so closely packed together, and painted over as soon as fixed, prevented the exudation of the moisture; and the intense heat of the sun during the summer months, as well as the vapor and sulphur from the locomotives and inefficient ventilation, assisted the fermentation going on inside the ribs, and caused rapid decay.

The scaffold for the construction of the roof, which I shall now briefly describe, contains altogether about 14,000 cubic feet of timber, and the estimated weight of it, when in full work, and including all iron and weights constantly being lifted, is 400 tons. It takes about 17 minutes to move it a distance of one bay, or 20 ft., out of which time the men take a rest of two or more minutes. The large wrought iron plate girders are constructed of such section that they may be hereafter used in bridges down the line. The stage has been designed so that no hindrance is caused to the traffic constantly passing underneath.

The wrought iron principals or main ribs are formed and accurately curved so as to fit in exactly between the old cast-iron shoes built in the walls on each side, the cast-iron spandrel fillings of the old roof being cut shorter to suit the new wrought iron ribs.

The intermediate ribs or rafters are of rolled iron 8 in. deep, with top and bottom flanges 5 in. wide and ½ in. thick all over; the lower ends are fitted with new cast-iron corbel shoes on stone templates built into the station wall, and the upper ends rest upon T-iron supports 5 in. by 2 in. by ⅜ in., and have wrought iron brackets riveted on each side, which are also riveted to the purlin stiffeners.

The first and sixth lattice purlins from the springing on each side are 1 ft. 6 in. deep, and formed of 5 in. by 4 in. by ½ in. T-iron flanges, with flat bar bracing 2½ in. by ½ in., and T-iron stiffeners 5 in. by 2 in. by ⅜ in. They are riveted at each end through the main ribs to each other, so as to be continuous from end to end. These purlins being of less depth than the main ribs, the difference (6 in.) is made up by a T-iron support 5 in. by 2in. by ⅜ in. riveted to the web of the principal.

The second, third, fourth, and fifth purlins on each side of the rib are formed of 5 in. by 4 in. by ½ in. T-iron bars, with 1⅛ in. tension bars and 1¼ in. struts. The ends of these purlins are fixed to angle-iron jaws riveted to main ribs, and to which also the ends of the tension bars are bolted.

In the last bay at the north end the purlins are of a stronger section, and composed of 5 in. by 4 in. by ½ in. T-iron for the flanges, and 5 in. by 2 in. by ⅜ in. T-iron bracing bars to sustain the lateral thrust of the roof, and the intermediate rafter in this bay is carried over from wall to wall.

An angle iron bar 6 in. by 3 in. by ⅜ in. is riveted to the top of the first purlin on each side, and a ventilating opening formed above it, by means of flat bars bent to horse-shoe shape, and carrying an angle iron bar 2½ in. by 2½ in. by ⅜ in., to which the glazing bars are riveted, the latter being inverted T-irons 3 in. by 1¾ in. by ⅜ in.

A double angle or Z-bar 4 in. by 2 in. by ⅜ in. is riveted on the top of the second, third, fourth, and fifth purlins on each side, and to the main ribs where they occur, to which the glazing bars are riveted, and are fixed in their place so as to give a perfect bed for carrying the glazing bars.

An angle iron bar 6 in. by 3in. by ⅜ in. is riveted along the top of the sixth purlin on each side, and to the main rib where they occur, to which T-iron arched bearers 4 in. by 3 in. by ½ in. are riveted to carry the raised portion of the roof for ventilation. On the arched bearers longitudinal angle irons 4 in. by 2 in. by ⅜ in. are riveted for carrying the glazing bars. At the centre these angle-irons are 9 in. apart, and the open spaces are covered with a wrought iron capping, No. 12, B. W. G., secured by brackets 1¼ in. by ¼ in. every 3 ft. 3 in. apart. The main ribs are 20 ft. apart, centre to centre, and are hoisted to place in seven different pieces, and the total weight of iron work in one bay of 20 ft. is 17 tons 3 cwt. 2 qr. 14 lbs.

The whole of the wrought iron was specified to be of full scantling, and capable of bearing a tensile strain of at

least twenty tons to the square inch. All the plates in the flanges of the ribs are planed truly square on each edge, and those in the webs of the ribs are planed at their butting joints. The junctions of bars and angles and T-irons are fitted to butt truly together. The rivet holes throughout were specified to be punched one-sixteenth smaller than required, and rimered out to the proper size when fitted in place, and no drifting or other straining of the iron being allowed under any circumstances. The rivets, bolts, and nuts were specified to be of iron cable of bearing a tensile strain of at least twenty-four tons to the square inch. The bending of angle and T-irons and the riveting to be done hot.

The whole of the timber is of the very best red Riga, thoroughly seasoned.

Fir packings with stop chamfered edges, are fixed by 3 in. by ½ in. coach screws to the main and intermediate ribs. They are carefully bent to the curved portion of the ribs, and bedded down in thick white lead, those on top of the main rib being composed of No. 2 wrought and stop chamfered packing 6 in. by 3 in., and that on intermediate rib being 9 in. by 3 in., also wrought stop chamfered.

The roof, for its whole length, and to the height of the first purlin on each side, is covered with 1½in. wrought—one side grooved, tongued and chamfered—red Riga, boarding securely nailed down to the packings described above; and a wrought one-side fascia 11 in. by 1½ in. with chamfered edge, and scribed between the main and intermediate ribs, is fixed against the brickwork at the bottom of the boarding along each side on the inside of the roof.

RAILWAY BRIDGE AT HAVRE DE GRACE.

From "The American Railway Times."

One of the finest and most substantial examples of American railway bridge construction of the present day, is to be seen at Havre De Grace, where the Philadelphia, Wilmington, and Baltimore railway crosses the Susquehanna river. The transit was formerly conducted with train ferry boats, which were frequently exposed to danger upon their passage, the river at this point being about 3,300 ft. in width. The bridge which was constructed from the designs and under the superintendence of Mr. G. A. Parker, C. E., is of timber, mainly on the Howe principle of truss. It consists of twelve spans of 250 ft. 9 in. in the clear, and a draw span of 174 ft. 9 in. The total length between the abutment piers is 3,273 ft. 9 in. The superstructure is supported by thirteen piers built of stone laid in cement, with caissons of boiler plate which reach to a short height above the line of the floating ice. From this point the piers are finished with dressed masonry laid in courses. The draw pier is circular and is 24 ft. 8 in. in diameter at the top of the caisson. The other piers are each 35 ft. 4 in. in length, and 8 ft. in width at the top of the caissons, and have a width of 7 ft. 3 in. at the top of the masonry. Besides the piers which carry the superstructure, there are at the draw span two guard piers, one above and one below, and which serve to protect the draw pier from injury, and aid ships in passing. The unstable nature of some parts of the bed of the river, together with the unusual depth of the water, and the occasional violence of the ice freshets at the point where the bridge is carried across, has surrounded the work with many engineering difficulties. The method adopted in constructing the piers was specially resolved upon in order to meet the exigencies of the case, and the results have been thoroughly satisfactory. The masonry was laid within wrought iron water-tight caissons, which were fastened to timber platforms and lowered gradually as the building of the masonry progressed on to a prepared foundation of piles. In some instances, the lowering was assisted by screws; in others the work was guided to the bottom by temporary guide piles. One of the piers was lowered by means of six 3½ in. screws, 56 ft. in length, to a pile foundation in water generally over 40 ft. deep. The cost of this fine structure was nearly £400,000, and, considering it is only a single-way bridge, wood-built, and on a line of railway only 100 miles in length,

this is a very large amount. But the public are great gainers by it, inasmuch as the time of travel is greatly shortened between Philadelphia and Baltimore, as well as on account of the absence of danger which previously existed in the old ferry passage. It occupied a thousand men four years in constructing, and, considering all the engineering difficulties encountered and successfully overcome, as well as the convenience afforded to the public by the bridge, we may pronounce it one of the leading engineering works of the age.

The above from the London "Mechanics' Magazine" pays a handsome tribute to the engineering skill shown in the construction of this bridge; but we seriously hope that this particular bridge will be the last wooden bridge in the United States of any considerable size for railway purposes, that our contemporary will have an opportunity for commenting upon. The adoption of so perishable a material in lieu of iron, we think will be found a great mistake —not a mistake of the engineer, perhaps, because probably the material of the superstructure was dictated by others, or by considerations over which he had no control. We trust the use of wood in the construction of long railway bridges is past. For ultimate economy, and for safety, there is no question which has not been settled in favor of iron.

RELATIVE ILLUMINATING POWER OF DIFFERENT SUBSTANCES.

From "The Practical Mechanic's Journal."

Taking as the unit of comparison the light given forth by the consumption in the usual form of lamp of one imperial gallon of Young's paraffine oil, Dr. Frankland has stated that to produce the same quantity of light 1.26 gallons of petroleum (*i.e.* natural oil) must be consumed. That also a total of light equal to either of the above is produced in burning by 18.6 lbs. avoir. of paraffine candles, 22.9 lbs. avoir. of sperm candles, 26.4 lbs. avoir. of bleached wax candles, 27.6 lbs. avoir. of stearine candles, or 39 lbs. of tallow candles. The great economy of those liquid hydrocarbons is sufficiently evident, though there can be no doubt that the deficiencies in luminiferous power of the candles is due in great part to their *being* candles, and not *liquids* burning with the advantages of a lamp.

But even this is not all that can be said in favor of the liquids. The light-giving power of candles scarcely admits of any material improvement,—to increase the light is to increase the intensity of the heat of the flame, which is to swill and waste the substance of the candle. In the liquids, however, there is no mechanical or chemical difficulty in increasing the quantity of light, to an extent of which we venture to say no clear notion has yet been formed, by employing oxygen wholly or partly in place of atmospheric air as the supporter of the flame.

Now that oxygen can readily be obtained by means of permanganate of lime at a price low enough to admit of its domestic use, we do not know of a more fruitful-looking speculation for those engaged in the improvement of instruments of illumination than to devise a paraffine oil-burning portable lamp, with a portable supply of compressed oxygen, to burn a known number of hours. The danger of using such a lamp, once properly constructed, would probably be less than that of the common camphene or petroleum lamps of the shops; for most of the accidents have arisen from awkwardness in upsetting these lamps in filling or lighting them, or with the oil-cans in filling. With oxy-paraffine oil lamps, the whole lamp should be delivered at the house of the consumer ready for use, and as with its oxygen reservoir it would be heavier and more bulky than the present lamps, so would it be safer as to upsetting, and accidents while filling put an end to. The same objections as against the blinding intensity of the focus of light in oxy-hydrocarbon lights as respects their use in public places, do not apply to their use in apartments, where the light may and ought always to be above the eye and shaded.

When we consider what is done easily, habitually, and at a profit, in Paris, in de-

livering about that city aërated water in "siphons" or gazogene bottles, and also frozen caraffas, *i.e.*, bottles of common water solidified into a block for cooling other water or liquors, of which alone half a million caraffas are said to be circulated daily in summer time in Paris, we see sufficient indications of what may be done at a profit in supplying from central depots other domestic implements, such as those for giving light. It no doubt will occur to every one that such a project would find a powerful competitor in the existing gas companies; these companies, however, do, and no doubt will continue as long as they can in their old jog-trot; they give, in London at least, gas of miserably bad illuminating power, and are not likely to attempt any radical methods of making it more luminiferous in the houses of the consumers. It does not follow that, although cheap as gas, such as it is, may relatively be yet, measured by the light afforded for 20s. sterling, paraffine oil, well burnt with oxygen, might not give the same light much cheaper. This much is certain, that it would afford whatever illumination could be needed, in a far more wholesome way than it is obtained by the consumer of London gas. How it is that public checks and counter checks, and all the apparatus of public officers paid for testing and reporting upon the qualities of our London gas, seem to be costly methods of finding berths for officials whose reports have no result, and indeed seem to be generally of the mildest and most "how not to do it" character, we are too much outsiders to know or even guess. But from unhappy personal experience we can (through the winter) testify that the gas supplied to London and to the south side in particular, is such as ought not be tolerated for a day, and such as would not be tolerated in Paris or Berlin, nor indeed in any capital but London, where genuine municipal jurisdiction and real action in such matters seems to be a succession of costly shams; or in New York, where it is said to be so corrupt that bribery is the rule and can do what it pleases. Possibly, something of the sort even here is not unknown to gas manufacturers, and certain revelations of a year or two ago as to the surveillance of gas company directors over their own *employés*, were not calculated to add confidence to the public as to what goes on to influence the character of the final product which reaches their parlor gas-burners. The fact is, however, that London gas at the south side, and we believe it is no better in other quarters (unless in exceptional cases and at exceptional prices), is so loaded with impurities that silver plate left out upon a sideboard is tarnished brown in a single night of damp weather, and within a fortnight in winter becomes absolutely black with sulphuret of silver deposit, while the ammonia present is sufficient to eat through and through any thin pieces of brasswork exposed above the gas flames, in a very few months; gilding also is rapidly and irremediably tarnished by action upon the alloy in the gold, as the microscope proves.

To prattle of sanitary care for the public, and yet leave, or rather compel them, for they have no remedy, to breathe the air of rooms in which such gas as this is consumed and such products evolved, is monstrously absurd. Were the public once assured that they could obtain good and ample light from paraffine, which holds neither sulphur nor nitrogen compounds, to damage their health and their property, and at a cost not much exceeding that of coal gas, for equal yields of light, it would soon go hard with the present gas-making interests and gas-supervising philosophers, or all of them would have to mend their ways.

Treatment of the Sewage of the City of Rheims.—MM. Houzeau, Devēdeis, and Holden, in a lengthy paper in "Les Mondes," detail the results of a series of experiments made on a sufficiently large scale to form a proper opinion as to value and permanent applicability. The processes which have been applied are: (1) Treatment with sulphate of iron and lime; (2) treatment with lignite and lime; (3) treatment with small coal (dust, rather) and a small quantity of sulphate of iron and lime. The two first processess yield a manure; the last a fuel. The city of Rheims is situated on and near the banks of the Vesle, and contains, exclusive of the large garrison, a population of about 61,000 inhabitants. According to a report of M. Maridort, Professor of Chemistry at this place, the process, by means of the use of lignite, is a complete success.

MANUFACTURE OF WHITE LEAD.

From "The Mechanics' Magazine."

White lead is generally manufactured in England by placing the metal over earthenware pots containing an acid, piling them up in layers and covering them over with spent tan. An improvement upon this somewhat slow process has been patented by Mr. Joseph Major, of Middlesex, in conjunction with Mr. W. Wright and Mr. G. H. Jones. The invention consists in the manufacture of white lead in closed chambers, heated artificially, and without the employment of spent tan or earthenware pots. The necessary vapors and gases are fed into the chambers containing the compounds to be converted into white lead. The invention further relates to the uses of the vapors and gases under pressure in a closed chamber, although the white lead can be produced by this invention without the gases and vapors being submitted to pressure, but more time is necessary.

The apparatus employed in the manufacture embraces independent apparatus for freeing the vapors and gases and for regulating their supply, and for keeping the lead in continuous circulation through the closed chambers. This is accomplished by revolving surfaces inside a chamber actuated by machinery, upon which surface the lead is placed. The invention further consists in a method of treating the white lead, when produced, so as to decompose and remove any remaining acetic compound and replace the necessity of washing the material. This is accomplished by currents of heated vapor or gases and air brought in contact with the material in the closed chambers, and circulating through them in contact with the materials, so as to deprive them of any superfluous compounds. They can, however, be washed and finished in the ordinary way. The article thus manufactured is completed by any of the well-known methods.

In our engraving Fig. 1 represents chambers constructed for carrying out the first part of this invention. A A^1 represents the chambers; B B the wall; C C the roof; and D the separating wall. These chambers are shown with different arrangements of the shelves, for causing the gases to circulate perfectly and to permeate in a complete manner the lead under process of conversion into white lead. The chamber A has shelves, *a a*, made of any suitable material, so disposed as to cause the vapors and gases to circulate in the direction shown by the arrows, as well as to permeate directly through from the top to the bottom, or *vice versa*. The second chamber, A , shows an arrangement by which the circulation is effected longitudinally. Steam is supplied to these chambers both for heating and for furnishing moisture by the pipes, *b b*, shown in the chamber A. *c c* are the flues, so contrived as to cause the heated gases circulating through them to pass through several chambers or through one only, or to the chimney, *d*, without passing upwards through the chambers, the course of the currents of heated gases being regulated by the dampers shown in the flues, *c c*. The lead is placed upon the shelves, *a a*. The vapor of water and ammonia and acids and gases generated from carbonaceous materials for furnishing carbonic acid are fed into the chambers, A A^1.

The mode of providing the necessary carbonic gases to the chambers is as follows: C^1 is a charcoal or fuel burner and furnace, made so as to be self-feeding by the upper box, D^1 D^1, and provided with a supply pipe, E, by which the combustion may be sustained by pressure from a fan. F is an oxidizing valve, which regulates the air admitted for effecting the combustion of the fuel. The products of this combustion pass under and through the boiler, H, by the internal flue, G. The products, after passing through the boiler, pass under the vessels for generating the gases. One of these generators is shown at L. M is a pouring pipe; N is an exit pipe; K a steam pipe adapted to the generator. By the generator gases can be made and sent to the chambers, A A^1 by the pipe, N. P represents an auxiliary exit or chimney used as a by-pass when necessary, as when the combustion is needed in the furnace, C^1, and the products are not wanted to circulate through the chambers, A A^1; *d* is the working chimney, which receives the products from the chambers by either of the valves, c^1 c^1, for sealing the chambers when required; I is the main steam pipe.

FIG. 3

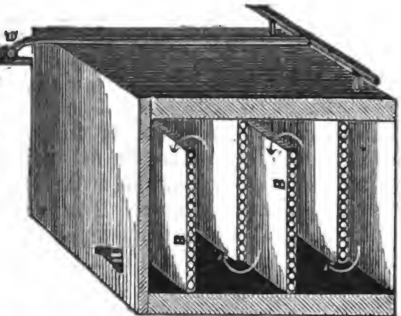


FIG. 1

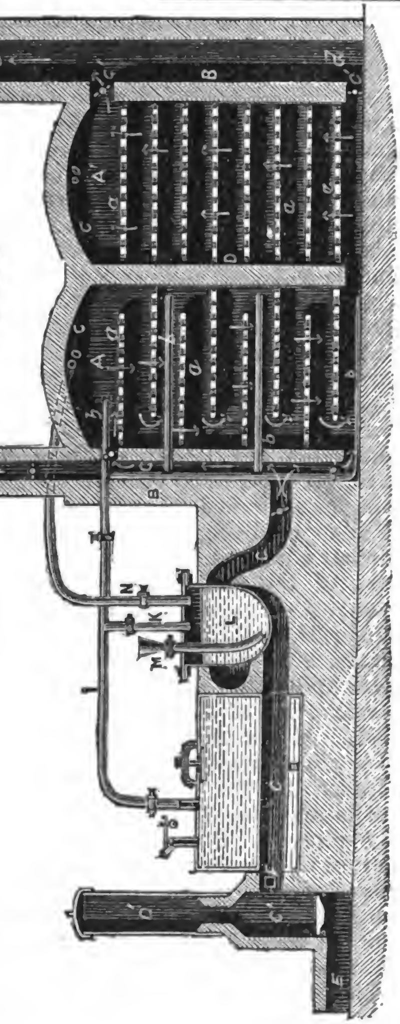


FIG. 4

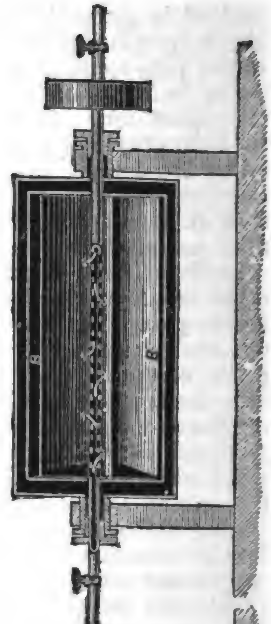


FIG. 5

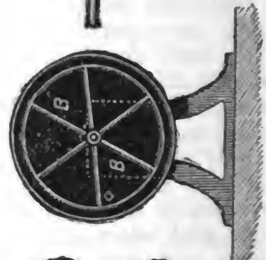
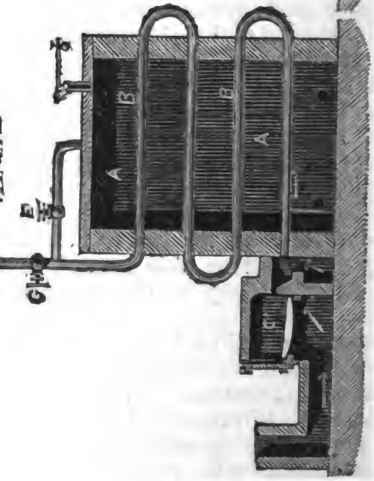


FIG. 2



The mode of operating is as follows:— The lead, which is prepared so as to expose a large amount of surface, is placed on the shelves in the chambers; the chambers are then closed, and heated to a temperature of about 120 deg. to 140 deg. Fahr. Steam is then directed into the chambers so as to convert a portion of the metal into hydrated oxide or oxide; this is continued for from ten to twenty hours. The chambers being raised to a temperature of about 120 deg. to 140 deg. Fahr., the next step is to generate vapors in the generator, L. These vapors are conducted by the pipe, N, to the upper part of the chambers at O. In these operations a sub-salt of lead is produced upon the lead in the chamber. The next step is to treat the lead with carbonic acid. This gas is prepared in the fuel burner, C^1, and is fed into the chambers and caused to circulate regularly in contact with the materials so as to convert the sub-salts into carbonate of lead. During the conversion of the lead in these stages of the operation, the temperature of the chamber is preserved at about 140 deg. Fahr., and the successive steps of the operation are repeated, care being exercised to regulate the supply of steam so as not to wash the lead nor to have it in too dry a state for treatment until the whole is converted into white lead.

Fig. 2 shows the arrangement of a pressure chamber, A, fitted with valves, E E, for the purpose of regulating the pressure within. B B are pipes for circulating steam from a boiler, or hot air and gases from the fuel burner, C, and forming also the shelves or supports for the lead. These pipes communicate with the chimney at D, which is provided with a stop valve, G, so that the products of combustion, after passing through the pipes of the chamber and heating it, can be forced into the interior of the chamber and brought in contact with the lead, and thus after being employed as a means of heating the chamber when the same is heated by the gases from the fuel burner C, these gases are utilized in the decomposition of the sub-salts and in the formation of white lead; the heated gases, however, may be employed for heating purposes alone, and carbonic acid supplied to the chamber from some independent source in a heated condition or not. Fig. 3 shows the arrangement of the shelves in the chambers so as to cause circulation of the gases within it, the course of these currents being at right angles to those within the hollow shelves or pipes through which the heating current passes, and on which the lead or its compound is placed. The mode of operating is the same in the pressure chambers as that already described.

When circulating chambers are employed, in which the metal is kept in motion, the inventors have two cylinders, as shown in Figs. 4 and 5; the inner one, which contains the lead, is made to rotate. It is a cylindrical vessel, B, with a number of radial shelves or gratings on which the lead is placed. These chambers are all fitted in a similar manner to those we have already described, and are fed with gases or vapors in a similar manner. The whole of the chambers have air-tight doors or openings for charging and discharging materials in manufacture.

White lead so manufactured can be finished in the usual manner by washing, grinding, etc., but the inventors treat their products in a novel manner and on a new principle. They decompose any salts of lead remaining other than those proper to white lead, and this they accomplish as follows:—They pass into the chambers when containing the lead compounds produced in manufacture, ammoniacal compounds, and so decompose any remaining salts of lead other than those proper to white lead. After this treatment they raise the temperature of the chamber and its contents so as to remove the ammoniacal compound so formed, and thus avoid the necessity of washing. The lead is afterwards finished and prepared for general uses in the customary manner. White lead manufactured according to this invention is said to be free from all contamination, and is pure white lead. The process relieves the operation from its present dangerous tendencies, the workmen are never exposed to any dangerous or deadly fumes, nor is there any chance of loss of material in the process of manufacture. Time is also economized, the usual period required being about three months, whereas the inventors state that they can fully operate upon lead so as to convert it into white lead in from fourteen to twenty-eight days, according

to the substance of the material operated upon, and in a pressure chamber they can produce it in even less time.

Professor E. V. Gardner, of Berners College, Oxford street, has practically carried out this patent in all its bearings, and his exhaustive report is now before us. Upon all points the Professor obtained the most satisfactory results, as will be seen by the following extracts from his report: "I do not hesitate to state, from my experience in these experiments, which I would observe are not laboratory experiments but practical operations (the chamber fully worked out being 4 ft. by 2 ft. 6 in. by 2 ft. 6 in., and containing 3 cwt. of lead), that white lead could be made by Major's process in 28 days—*i.e.*, if the process were well conducted day and night unceasingly, and no time lost in raising the heat of the chambers day by day, as has been unavoidably the case in these experiments. I am also of opinion that the conduct of this process on an extensive scale, say of 500 or 1,000 tons, would show even more favorable results, and afford means of large and economical reductions in the cost of manufacture." Concerning the finishing process, the Professor writes: "According to the plan at present pursued in making and finishing white lead, the material from the converting vessels being washed and ground, the cost is about $7 per ton. By this process (according to Major's patent) the converted material is treated with vapor of ammonia, so that any remaining acetate is decomposed; the salts of ammonia thus formed are then removed by currents of heated air, or by superheated steam. This newly improved finishing process, it is to be observed, is completed without removing the converted material from the chambers in which it has been treated."

RAILWAY BRAKES.

From "Engineering."

A railway train moving at a speed of 60 miles per hour, or 88 ft. per second, has the same velocity as a body would acquire in falling freely from a height of 120.25 ft.; and if it were possible to change the direction of its motion so that it should be projected directly upwards, it would, if not checked by frictional or other resistances apart from that of gravity, rise vertically to the height just mentioned before coming to a state of rest. In other words, for each pound of the train's weight there are 120.25 foot-pounds of "work" which must be expended, either in overcoming the frictional resistance caused by the brakes, or in some other way, before the train can be brought to a stand. Again, a train moving at a speed of 30 miles per hour, or 44 ft. per second, has the same velocity as a body would acquire in falling from a height of 30.06 ft.; and there are therefore but 30.06 foot-pounds of "work" stored up in it for each pound of its weight, and the work to be done in stopping it is thus only one-fourth of that required in the first example. The work to be done in stopping a railway train, in fact, varies, as is—or ought to be—well known, as the square of the speed at which it is moving; and this being the case, it is of the utmost importance that in all experiments made to be determine the relative value of different railway brakes, the speed at which the train is moving when the brake is applied should be known exactly, and not merely guessed at, as happens in but too many instances.

The manner in which a slight error in the determination of the speed at the time the brake is applied will totally destroy the value of the results obtained, is clearly shown by the subjoined table. In this table the first column shows the speed of the train in miles per hour; the second column the equivalent velocity in feet per second; and the third column the height, in feet, from which a body must fall freely in order to acquire the velocity given in the preceding columns. If now it was possible to apply to a railway train in motion a steady resisting force equal to its own weight, this would be equivalent to changing the direction of its motion to a vertical one, and the train would be brough to a state of rest after having passed through a space equal to the height given in the third column of the table. Practically, however, it is impossible to oppose such a resistance as

this to the motion of a railway train—at all events on ordinary railways—and the most that can be done (unless the engine is reversed and steam admitted against the pistons) is to employ continuous brakes, and apply brake blocks to all the wheels of the train simultaneously, the pressure of the blocks being regulated so that the wheels, although just on the point of skidding, are not actually skidded. Even this result could not be obtained—unless accidentally—in regular working, for of course the pressure which would produce skidding of the wheels in one state of the rails would not do so in another, and, moreover, no system of continuous brakes would enable the pressure of each brake block on its wheel to be accurately adjusted according to the load that wheel might be carrying at the time of the brake being applied.

Practically, however, we may assume

Speed of train in miles per hour.	Speed of train in feet per second.	Height from which a body would have to fall to acquire the velocity given in preceding column.	Distance which would be run by the train against an opposing resistance of 10 lbs. per ton or 1-224th of its weight.	Time occupied in running the distance given in the preceding column.	Distance which would be run by the train against an opposing resistance of 224 lbs. per ton or 1-10th of its weight.	Time occupied in running the distance given in the preceding column.	Distance which would be run by a train against an opposing resistance of 448 lbs. per ton, or 1-5th of its weight.	Time occupied in running the distance given in preceding column.
Miles.	feet.	feet.	feet.	m. s.	feet.	sec.	feet.	sec.
60	88.	120.25	26,936	10 2	1,202.5	27.3	601.7	13.7
55	80.7	101.12	22,650.8	9 21	1,011.2	25.	505.6	12.5
50	73.3	83.6	18,726.4	8 30	836.	22.7	418.	11.4
45	66.	67.6	15,142.4	7 39	676.	20.4	338.	10.2
40	58 7	53.5	11,984	6 48	535.	18.2	267.5	9.1
35	51.3	40.86	9,152.6	5 57	408.6	15.9	204.3	7.9
30	44.	30.06	6,733.4	5 6	300.6	13.7	150.3	6.8
25	36.7	20.9	4,681.6	4 15	209.	11.4	104.5	5.7
20	29.3	13.3	2,979.2	3 24	133.	9.1	66.5	4.5
15	22.	7.5	1,680	2 33	75.	6.8	37.5	3.4
10	14.7	3.35	750	1 42	33.5	4.5	16.7	2.3
5	7.3	0.83	186	0 51	8.3	2.3	4.1	1.1

that, unless the rails are in a very "greasy" state, the use of a good system of continuous brake applied to all the wheels of a train will give a retarding force equal to one-fifth the weight of the latter, while if the brake-blocks are applied to half the wheels only, the retarding force will equal one-tenth of the weight of the train, and so on; the variation in these amounts due to atmospheric resistance being disregarded in the following calculations, as their consideration would only lead to unnecessary complications. This being the case, let us now see how an error in determining the speed at the moment the brake is applied, will effect the result obtained. If a train is subjected to a retarding force equal to one-fifth of its own weight, the space through which it will pass before being brought to a state of rest will be five times as great as if the retarding force was equal to the weight of the train; or, in other words, the distance it will traverse will be five times that placed opposite the corresponding speed in the the third column of our table; or will be equal to that found in the eighth column of the latter. This space is the minimum distance in which a train running on a level line could be brought to a stand by a resistance equal to one-fifth of its weight; and in practice the distance run by the train before the stoppage is effected will always be greater than this, on account of the time lost in causing the brake blocks to exert the requisite pressure upon the wheels. The more perfect the arrangement of the brake the less this loss of time is; and in comparative trials, therefore, it is of importance to determine this loss accurately; but, as we shall now show, it is quite impossible to ascertain this loss with any degree of accuracy, unless the observers have a precise knowledge of the speed at which the train is moving.

For instance, let us suppose that a

train, moving at the rate of 55 miles per hour on a level, to be brought to stand after having run a distance of 1,000 ft. past the point at which the brake was applied, the brake being so constructed as to bring into action a retarding force equal to one-fifth the weight of the train. Referring to our table, it will be seen that a train, moving at 55 miles per hour, would run 505.6 ft. against an opposing resistance equal to one-fifth its weight; and it follows, therefore, that in the case supposed in our example the train must have run 1,000—505.6=494.4 ft. before the brake was brought into action.* The speed of 55 miles per hour is equal to 80.7 ft. per second, and the time lost in applying the brake would thus be $\frac{494.4}{80.7}=$ 6.12 seconds. Let us suppose now that the observers in the case we are imagining, instead of taking the speed of the train at its correct amount, namely, 55 miles per hour, had estimated it at 60 miles per hour, equal to 88 ft. per second. Under these circumstances the distance to be set down as that which would be run by the train against a resistance equal to one-fifth its weight would be—as will be seen from the table—601.7 ft., and this distance subtracted from the 1,000 ft. leaves 398.3 ft. as the distance run by the train before the brake was got fairly to work; while, the speed being supposed to be 88 ft. per second, the time corresponding to this distance will be $\frac{398.3}{88}=$ 4.52 seconds, or about 27 per cent. less than what we have shown to be the real time. At lower speeds than those we have chosen for our examples a mistake to the extent of 5 miles per hour in estimating the speeds would lead to still more serious errors, as our table clearly shows.

In the foregoing examples we have assumed—for the purpose of showing more clearly the influence of an error in the determination of the speed—that the retarding force of the brake was equal to one-fifth of the weight of the train; and we shall now proceed to explain how, in practice, the amount of retarding force actually applied can be correctly ascertained, it being premised that in order to do this it is absolutely necessary that the train should be fitted with an accurate speed indicator. This being the case, let the brake be applied, and after it is fairly in action, and the train becoming retarded, let the speed, on passing some definite object, be accurately noted. This being done, and the distance run by the train past this object before stopping being subsequenty measured, we have all the elements for calculating the retarding force. Let us suppose, for instance, the speed of the train on passing the object, to have been 30 miles per hour, and the distance subsequently run 200 ft., then referring the table (third column) we find the distance which would have been run, if the retarding force had been equal to the weight of the train, would have been 30.06 ft., and dividing 200 ft. by this we get $\frac{200}{30.06}=6.65$, or the retarding force must have been equal to $\frac{1}{6.65}$ equal to 15.037 per cent. of the weight of the train. If the train should be running up or down a gradient when this experiment is made, the result obtained should be reduced to the equivalent result on a level by deducting or adding, as the case may be, the retarding force, or the force tending to assist the forward motion of the train, due to the gradient. Thus, if the train was *ascending* an incline of 1 in 100 at the time the above experiment was made, 1 per cent. would have to be deducted from the retarding force, calculated in the manner we have explained, in order to get the equivalent retarding force of the brake on a level line; while, if the experiment was made on a *descending* gradient of 1 in 100, 1 per cent. would have to be added to the calculated result. The actual retarding force being known, the time lost in applying the brake can be readily ascertained in the manner we have already explained.

Although there are many cases in which, for the purpose of ascertaining the comparative value of different classes of brakes, it is desirable that the time lost in bringing the apparatus into action should be separated from that required to stop the train after the brake-blocks are actually applied, yet in the majority

* In this and the following calculation we have, for the purpose of simplifying matters, supposed that the pressure of the brake-blocks is applied to the wheels suddenly, instead of gradually. In reality the brake-blocks begin to exercise a retarding force from the time they first touch the wheels, the force becoming greater as the pressure applied to the blocks becomes more intense; but in our examples we have supposed the full pressure to be exerted at once, and that there is no retarding force until this pressure is attained.

of instances, probably, railway men are content to ascertain that a train fitted with brake-blocks on so many wheels, can, when moving at a certain speed, be brought to a state of rest within a certain distance; and they value the brake accordingly. In this case an excellent estimate of the value of any given brake may be obtained by measuring the distance run by the train after its application, and dividing this distance by that which the train would have run if the retarding force had been equal to its own weight. For instance, let us suppose that a train moving at the speed of 40 miles per hour, runs a distance of 500 ft. after the application of the brake; then, referring to the table, it will be seen that the distance in which a train would stop under such circumstances, if subjected to a retarding force equal to its own weight, would be 53.5 ft., and dividing 500 by this, we get $\frac{500}{53.5} =$ 9.32, this number forming a kind of "figure of merit," by which the performance of this brake can be compared with others, the *lower* this figure the better being the performance. In making this comparison, however, it must be borne in mind that it is not a fair one unless the brakes between which it is instituted are both applied to the same proportionate number of wheels of the train; neither does it form a good method of comparing brakes tried at widely different speeds, some brakes giving far better "figures of merit" at low speeds than high ones, while others give much more nearly equal figures at all speeds. This, however, is a matter of which we intend to speak on a future occasion, when we shall treat of the manner in which the construction of a brake affects its efficiency at different speeds. In conclusion, we may remark that in calculating the "figures of merit" just mentioned, accurate information as to the speed of the train when the brake is applied is absolutely essential to give them any value. For instance, if in the example we have given, the speed had been wrongly estimated at 35 instead of 40 miles per hour, the divisor would have become 40.86, and the "figure of merit" instead of being 9.32 would have been $\frac{500}{40.86} = 12.23$, a widely different result.

THE USE OF GAS AS FUEL.

From "The American Gas-Light Journal."

During the last few years heating with gas in different ways has been introduced, and doubtless this mode of heating would enjoy a far more extensive application on account of its cleanliness and simplicity, were it not for the high price of illuminating gas on the one hand, and the impracticability of generating gas on the principle of Sieman's gas generator, on a small scale, on the other hand. The supply of a cheap article seems, therefore, very desirable; and this object we learn is about to be realized by the gas works now building at Furstenwald near Berlin. The gas is to be generated from lignites at Furstenwald, about twenty-two miles from Berlin, and carried to the latter city by means of pipes. For this purpose there will be erected at Furstenwald 12 buildings, each 105 by 62 feet, with an aggregate of seventy furnaces, each containing 10 retorts. The furnaces will be provided with Sieman's regenerator. The gas after having been freed from tar, water, etc., by passing through condensers, is brought to Berlin through a series of pipes 4 ft. in diameter, into which it is forced by 4 cylinder-blasts of 7 ft. 7½ inches diameter and 6 ft. stroke. The blasts are propelled by 4 steam engines of 6 ft. stroke, and 360-horse power each—capable, however, of working up to 500-horse power. The pressure of the gas in the pipes is intended at 16 ft. water, equal to about 7 lbs. to the sq. in., since this comparatively high pressure allows of a smaller diameter of the pipes, and seems to offer a lower one in many other respects. The pipes are made of quarter-inch boiler plates, and not buried, but laid above ground, to render them at any time easily accessible, and supported in an appropriate manner by stone pillars. Under a pressure of 16 ft. water, the pipes will deliver 407 cubic ft. per second.

At Berlin the gas will be stored in 12 gasometers, each 154 ft. in diameter and 40 ft. high, having therefore a capacity

of about 750,000 cubic ft. From these gasometers the city is to be supplied. From experiments made by Dr. Zuirck of Berlin, it seems that a gas of good heating quality can be made from the Furstenwald lignites. The components of the gas at a specific gravity of 0.5451 is said to be as follows:

Hydrogen	42.36	per cent.
Carbonic oxide	40.00	" "
Heavy carburetted hydrogen	11.37	" "
Nitrogen	3.17	" "
Carbonic acid	2.01	" "
Carburetted hydrogen (condensable)	1.09	" "
	100.00	

If this composition of the gas can be regularly maintained throughout, it will answer its purpose perfectly. The experiment shows that 3,000 cubic ft. of gas are equal in heating power to one ton of lignite, or one-third ton of hard coal. The price at Berlin is rated at twelve and a half cents gold per thousand cubic ft., and the equivalent of one ton of hard coal will cost in Berlin \$1.12½ cts. gold. The capacity of the works are calculated at 9,500,000 cubic ft. per annum, or about ten and two-third millions per day, which it is said will cover the demand of about half the city.

ECONOMICAL STEAM-ENGINES.*

From "The Engineer."

Certain individuals hold that economy in the consumption of coal is the true and only test of the value of a steam-engine. They maintain, in pursuance of this theory, that complexity of arrangement, multiplication of parts, and increase of first cost, are not to be considered objectionable, provided the annual outlay on fuel is reduced to a minimum by their introduction into steam machinery. The gentlemen of this persuasion may be divided into two classes. The first is composed of men who never made or used a steam-engine in their lives, and probably never will—of pure theorists, in fact. The second is composed of mechanical engineers who make engines to sell. We do not use the words "to sell" in the invidious sense, but we can find no other phrase which so clearly defines the difference between the manufacturing engineer and the manufacturer, or steamship owner, who does not make but use steam-engines. Now, within certain limits, and under certain conditions, it is true that any steam engine using less fuel than any other engine of the same power, will be the best; but the advocates of extreme economy in the matter of fuel totally forget that there are conditions and circumstances which may render the employment of excessively economical engines, so far as fuel is concerned, excessively uneconomical in the long run. Those of our readers who are discriminating employers of steam power, and possess experience as manufacturers, or steamship owners, will have little difficulty in recognizing and defining these conditions; but it is, we think, worth while to say something on the subject for the possible benefit of those—either makers or owners of steam power—who know little of the true daily life of an engine.

It is generally understood that an engine consisting essentially of a cylinder and piston, crank and fly-wheel, slide-valve and condenser, Cornish boiler and furnace, and little else, will not get the greatest possible indicated power out of a given quantity of coal burned. It is possible, however, to get a horse-power per hour with a very simple condensing engine, from the combustion of 4 lbs. of good coal per hour. If we want to get more power from the same or a smaller consumption of fuel, we must introduce certain mechanical expedients specially intended to economize fuel. Thus, for example, we must have a separate expansion valve or its equivalent, a steam jacket, a high speed of piston, a very efficient condenser, a superheater, etc.; in return for which the consumption of steam, and, of course, of fuel, will be reduced. Some of these select mechanical expedients may be applied without necessarily risking the permanent efficiency of the machine; others cannot. And it is a very important point to decide which of them can be introduced with propriety under given conditions,

* See page 378.

and which cannot. In dealing with this question a broad principle may be laid down, which is that the multiplication of static steam economizers is never objectionable, superheaters excepted; while the multiplication of dynamic economizers is to be deprecated, or permitted only after due consideration has been paid to the nature of the work the engine has to do, and the qualifications of the men into whose hands it will fall. It will be proper here to define what we we mean by a static and what by a dynamic steam or fuel economizer. We cannot do this better than by giving an example. A steam jacket to a cylinder is a static steam economizer. It has no working parts, does not move, and, if properly made at first, will never cost one farthing for repairs or renewal. A dynamic economizer is, on the contrary, an expansion valve, a second piston, a peculiar air-pump—any moving part, in a word, which tends to increase the economical efficiency of a steam-engine.

It so happens that statical improvements are invariably productive of good, and should therefore in all cases be freely adopted. Their first cost, too, is comparatively moderate, and once supplied and paid for, we know that they need not cost another fraction. Unfortunately, the contrary is the truth, whatever may be said of so-called improvements of the dynamic character. At a very moderate additional outlay, all cylinders may be cast with a steam jacket, which will last as long as any part of the engine without costing a farthing for repairs, or endangering the good working of the machine for a moment. But of how few dynamical improvements can as much be said? The sole objection to the jacket lies in the fact that because its use causes the engine to work with dry steam, the cylinder may be cut up. With a very ordinary amount of attention no trouble will be experienced in this way; and should a cylinder face show signs of getting out of order, we have only to turn a tap, shut the steam out of the jacket, and wait a few days till the cylinder comes to a face again; which it will do if of good metal, and not allowed to get into very bad order. Again, improvements in the design or setting of boilers, in the proportioning of the area of steam-pipes and passages, and such like, may be all classed as statical improvements, and should be freely adopted under all conceivable circumstances, except in districts where coal can be had at nominal rates.

If we turn to the most economical engines, so called because they burn little coal, we find that in addition to—or very frequently instead of—statical improvements, we have a great number of dynamical improvements. In other words, there is a multiplication of moving parts, often accompanied by bad design, bearing surfaces deficient in area, and a general lack of strength in the parts, and of fitness to the intended purpose. Such engines never give as much satisfaction as would machines far plainer and simpler; and it is especially noteworthy that these complex engines are, after all, even in the matter of coal, often only apparently more economical than simpler engines. Th can maintain that a compound steam engine with a high and low pressure cylinder, two or three sets of slide and expansion valves, two sets of stuffing-boxes, etc., will work with as little internal friction as a single-cylinder engine of the same power and equally well made; yet the indicated power of the two engines may be identically the same, in which case the compound engine is doing less paying work than its rival; or the indicated power of the compound engine may be greater than that of the single-cylinder engine, though its useful work is not. This point is frequently overlooked, but it is one of considerable importance when we come to estimate the relative economical values of engines in decimals of a pound of fuel per horse per hour.

It is possible, we believe, in practice, to obtain a horse-power, indicated, from the consumption of a little over 22 lbs. of steam per horse-power per hour. But the engine which will do this ceases to be a practical machine, and becomes little more than a huge scientific toy. That it can be worked for a time with success in good hands no one will dispute, but in the long run no such complicated combination of cylinders, steam heaters, etc., etc., can prove generally satisfactory. The experience of Cornish engineers with excessively simple engines, is conclusive in showing that the engines which burn least coal in doing a given amount of pumping are not the most economical in the long run; and we have not the slightest doubt that if fuel and repair accounts were properly

kept elsewhere the conclusions of the Cornishmen would be freely endorsed by others. In all so-called improved economical engines with which we are acquainted there is a superfluity of what we must term trifling details—trifling, that is to say, in strength and dimensions, yet essential to the good working of the machine. The failure of any one of these may do infinite mischief. If we speak to the maker of such engines, and remark that such and such a detail appears likely to get out of order, the answer is, "Suppose it does, you stop your engine for an hour and replace it for 5s.—that is all." These gentlemen forget that to stop the engine driving a large factory is like stopping a man's heart. It is worth while to fix this fact—the evil results of a failure even in slight details—on the minds of our more youthful readers by citing a case in point. Last week we stood in a rolling mill in full swing. The engine, a very simple horizontal one, had just been started to roll off a heat with which two large furnaces were charged. Almost while the first bar was in the rolls, the brass spindle of the screw starting valve broke. The valve went down on its seat, the engine stopped, and nothing was left to be done but draw the piles from the furnaces and leave them to cool. Two hours were occupied in replacing the broken spindle. The cost of replacement was possibly 5s., but what was the loss caused by an entire mill standing still for two hours? What was the loss in fuel and iron? A hundred times the cost of replacing the broken spindle would not have paid the damage caused by its failure. Would not any man be insane who, to save a little fuel, adventured on the use of an engine constantly open to such casualties? Would it not be better to put down a good, plain, substantial engine, reasonably economical, on which he might pin his faith as certain to be always ready when wanted for years, even though it did burn a little more coal?

Another point to be considered in putting down a complex engine is this: If the engine is run constantly day and night throughout the year, as hundreds of engines are, sooner or later it will get out of repair in little things. Some of its many joints will begin to leak; some of its valves too want facing up; someof its parts will get out of line, and it will generally fall off in accuracy of performance. There is no time for a comple'e repair, and so it goes on as best it can; the immediate result of its defects being that its efficiency falls down at once to the level of that of a very ordinary type of engine indeed. We have then all the first cost, friction, and risk attending the use of a complex engine, and no counterbalancing advantage. We do not wish to be misunderstood. We believe that, under certain circumstances and conditions, it is advisable to pay a long price for an engine which shall be eminently economical in fuel, but we also hold that such conditions are more frequently absent than present. When an engine has but ten or twelve hours to work out of the twenty-four, when it is lightly loaded, when it is placed in the hands of first-rate attendants, and where coal is very dear, the introduction of a great deal of complication may be permissible. But in all the thousands of cases where an engine is heavily loaded, continuously worked, and when its continuous working is essential to the prosperity of the concern, dynamical appliances intended to save steam should be introduced with the utmost caution.

THE PRUSSIAN IRON TRADE.—The Prussian iron trade shows much activity; the demand for pig has, indeed, acquired such proportions that the blast furnaces can scarcely keep pace with the consumption. In consequence of an advance in the price of coke, and in consequence also of the diminished imports of English pig, the Prussian firms have raised their prices to some extent. There has been a good demand for merchants' iron upon the Prussian markets, and prices have advanced. Large orders for rails have been given out, as much as 37,500 tons being required for State lines in Northern Germany, and 12,500 tons for Southern Germany; the rail-rolling mills of Prussia will be fully employed for the whole year in the execution of these and other orders.—*Engineering.*

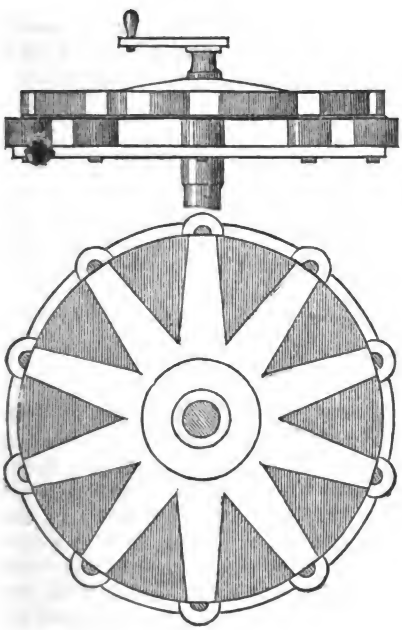
THE "London Times" is now printed on a new press of novel pattern, invented by Mr. Walter. It turns out 11,000 impressions, printed on both sides, in one hour. The Hoe press, heretofore the best, turns out but 7,000 impressions an hour.

SUBMARINE WARFARE*.

From "Engineering."

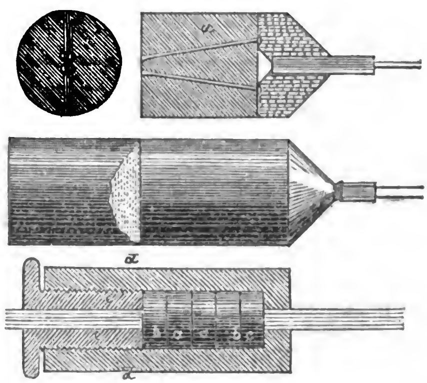
This is a truly excellent book, the result of much labor and research, the record of the most important advances that have been made in the development of submarine warfare, and the description of the principal experiments that have been made with defensive and offensive torpedoes that have been conducted on the other side of the Atlantic.

FIGS. 1, 2.



Tracing the history of submarine explosives from their commencement, the author attributes to an American, the first practical experiments in destroying ships by the application to their sides below the water-line, of sumerged powder-charges, and traces the subsequent labors of Robert Fulton in France, England, and America. Sketching the gradual advancement of the new branch of military science up to the date of and through the Russian war, the author passes on to the consideration of the numerous devices, generally so effectual, which marked characteristically the American civil war, and which, at first condemned as weapons unworthy of a civilized nation, became at last recognized as legitimate means of offence and defence. During that prolonged conflict, the ever-increasing difficulties of the Southern army, and their straitened means, drove them to the adoption of torpedoes to a much greater extent than their antagonists, whose marine suffered to a terrible extent. After the termination of the war, the mutual experience became available, supplied

FIGS. 3, 4.



on the one hand from the South, whose ingenuity had schemed the means of destruction, and by the North on the other, whose ships had been annihilated, and whom necessity had taught how best to avoid the unseen dangers which had beset the river and the seaboard, during the season of hostilities, as well as how to seek for and render harmless the set torpedoes, and how to destroy submarine obstructions.

We need not further allude in this place to the various designs of the torpedoes used during that time, because we shall publish shortly drawings of the principal forms, but will pass on to the latter portion of Commander Barnes's book, treating on electric torpedoes, submarine guns, and obstruction destroyers.

Although Fulton had conceived the possibility of employing electricity as a means for exploding torpedoes at will, and the Royal George had been partially destroyed in 1839 by that means, the

* "Submarine Warfare, Offensive and Defensive, including a Discussion of the Offensive Torpedo System; its effects upon Ironclad Ship Systems, and Influence upon Future Naval Wars." By Lieutenant-Commander J. S. Barnes, U. S. N. New York: D. Van Nostrand. London: E. & F. N. Spon, Charing-cross.

Russians were the first to systematize this system in its application to harbor defences, without, however, producing any effective result. Before 1851, Austrian engineers had employed this agent for the purpose of igniting charges, and with great success, experimentally, in conjunction with Colonel Scholl's fuse, an arrangement consisting of a wooden bar, terminating in a wooden cone, hollow, and containing an igniting charge of gun-cotton, which is in contact with the wires of the battery. These wires, passing through the cone, lie within grooves cut into the sides of the fuse for its whole length, and convey the spark through the gun-cotton, by which the latter is ignited. When a copper wire has been covered for some time with vulcanized gutta-percha, the interior of the tube, on withdrawing the wire, remains covered with a thin layer of sulphide of copper, which is a moderately good conductor of electricity. If a section of the tube thus formed be interposed between the ends of the conducting wires, and a current of sufficient intensity be caused to circulate through the wire, it will leave the wire at the break, and pass through the sulphide of copper; but here sufficient resistance will be met to ignite the sulphide, and, if it is in contact with gun-powder, will explode it. Upon this principle a fuse, much used during the Russian war, was employed. The ends of the copper wire are separated by .15 in., and placed within a gutta-percha tube, one side of which has

Fig. 5.

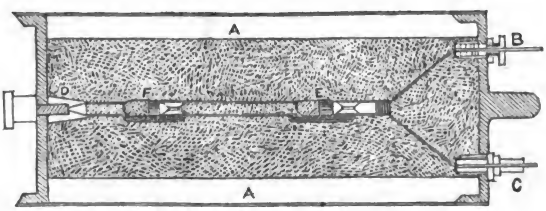
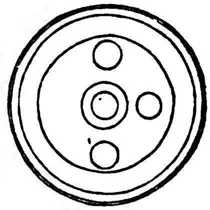


Fig. 6.



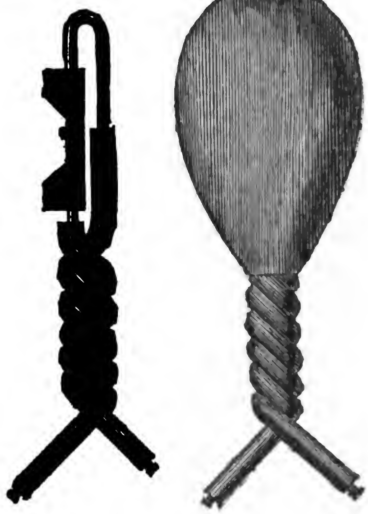
been partly cut away to bring it into direct contact with the priming powder. (Figs. 7, 8.) The space between the ends of the wire is filled with fulminate, which is ignited just as is the gun-cotton in Colonel Scholl's arrangement. In the same manner platina wire connecting the terminals of the conductors is found effective. Experiment has shown that the best results are obtained from a wire $\frac{4}{10}$ths of an in. long and $\frac{4}{1000}$th of an in. in diameter. By this arrangement powder can be ignited throuph the aid of a single element of the Bunsen battery at a distance of 155 yards.

Following the description of the various European torpedo magnetic exploders which are tolerably familiar to us, such as Verdu's, Breguet's, and Wheatstone's, the author passes on to the consideration of the best instruments which have been devised in the States for this work, and of which the one most in favor is that designed by Mr. G. W. Beardslee, of New York, an instrument like the Wheatstone exploder, but differing from it in mechanism and the arrangement of the magnets, by which it is claimed that a larger quantity, though a less intense current, is obtained than by the Wheatstone instrument. The Beardslee exploder is a radial magnet, with ten poles built up of cast-iron plates, collectively 1 in. thick, and measuring 15 in. from point to point, which are negative and positive poles alternately. The spaces between the arms are filled with wood, and the whole instrument is caused to rotate rapidly by gearing. The magnet is placed upon ten soft-iron cylinders, covered with fine silk-covered copper wire, 440 yards of which are coiled upon each of them. The ends of the coils are joined together, so that a continuous current can pass round any number of the cylinders, which can be arranged in sets according to the intensity required, or if quantity be the object, the coils are separated and each coil throws its current into a common conductor. (Figs. 1, 2.) In connection with this exploder is a fuse by the same inventor, which found great favor in the United States, and which is remarkable for its simplicity and certainty of action. Into a hard wood cylinder are driven two copper nails, converging, yet not in contact at the points, which are driven through

the wood. Connected with the heads of these nails are two insulated wires, and across the points of the copper conductors a groove is filed, and plumbago being rubbed within the grooves, the circuit from wire to wire is completed. A soft lead pencil drawn across the groove answers the purpose well, and a small charge of powder placed in connection with the plug completes the fuse. (Fig. 3.)

Two others of Mr. Beardslee's inventions may also be noted—a torpedo, of which the construction is shown in the accompanying sketch, and a union joint for coupling conducting wires. (Fig. 4.) In the latter the two strands of wire to be joined pass through two discs of metal, *a*, *a*, and two of hard rubber *b*, *b*, the whole being enclosed in a gutta-percha tube. The wires of each strand being separated radially, are spread over the face of each disc, and a metal washer, *c*, is placed at the bottom of the tube, the whole being kept tight by a screw plug of gutta-percha. In the torpedo, see Figs. 5 and 6, the case is made of galvanized iron, with cast-iron ends. The conducting wire passes through an india-rubber union at B, into the centre of the torpedo, and being fastened to the bottom of the machine, is connected to the ground wire, which returns through the torpedo, and passes out at the end by a brass union at C, the fuses being connected to the wires, as shown. The powder charge is contained within an inner chamber, surrounded by an air chamber. The value of the addition of an air chamber to torpedoes has given rise to long discussion, and considerable experiment in the States. The shell with an air space, designed by Messrs. W. W. Wood and Lay, of the United States Navy, in 1864, was afterwards advocated and adopted by Mr. Ericsson in the obstruction remover constructed by him, and the advantages claimed for the air chamber are, briefly, the power of directing and concentrating the force of an explosion, a buoyancy by means of which the shell is more easily managed, and its position better maintained, and a certainty that the entire charge can be consumed before the water can enter the casing and destroy the explosive. In a number of experiments conducted with torpedoes made on this principle, and loaded with charges varying from 40 to 60 lbs. of powder, the results obtained were so much in excess of what had been produced by the explosion of ordinary torpedoes with similar charges, that the advantages claimed by the inventors were apparently established.

Figs. 7, 8.



From a series of experiments, however, carried on at Willet's Point in 1865 by Major W. R. King, it is argued that the advantages of an air chamber, as claimed by Messrs. W. W. Wood and Lay, were much exaggerated. In the conclusions deduced from the experiments Major King says: "The results of the first series of trials indicate that an air chamber should not be interposed between the charge and the object to be destroyed. It is as easy to place the charge near the object as to place an air chamber there, and, in addition to the increased effect of the former arrangement, we have, by placing the air chamber below the charge, an additional security against moisture reaching the powder." We must confess, however, that the evidence based upon experiment, and brought forward in favor of, or against, the air chamber, is very limited, and insufficient to deduce any absolute conclusion. We shall, however, take an early opportunity of again referring to Major King's experiments, which are extremely interesting and useful.

In concluding our notice of this book, we must congratulate the author upon having excellently executed his task. He has put forth a volume alike interesting

to the professional and the casual reader, for the story of the submarine war of the United States is full of lively and unflagging interest, while the whole book must be regarded as an American torpedo manual, containing valuable information. Lieutenant Barnes has spared no labor to perfect this work, and has wrought upon it with the pen of an able and fluent writer.

RAIL TESTS ON THE NEW YORK CENTRAL.

From "The American Railway Times."

Mr. Editor,—I herewith hand a statement of tests recently made at West Albany, by the permission of Vice-President Torrance. Under the management of this gentleman, rail tests have become an institution on the New York Central, and the importance of these tests is best demonstrated by the fact, that since their introduction the rail section of that road has been changed from 4 in. height to 4½ in. for steel rails, and to 5 in. for iron rails. The tests herewith stated are made with rail pieces four feet long, all of similar section, and with exception of No. 1 and 2, 4½ in. high.

In comparing the tests, it must therefore be remembered that the 5 in. No. 1 and 2 rails should (theoretically) have

Rail Tests at the New York Central Machine Shops, West Albany, in presence of G. B. Van Voast, M. M. F. Roth, Alex. Elbers. Test by 2,240 lbs. drop. Bearings 3 ft. apart. Temperature 16 deg. Fahrenheit. Commencing at 1 foot drop; deflection in inches.

Number.		DROP IN FEET.										
		1	2	3	4	5	6	7	8	9	10	
1	Rail 5 ins. high, 69½ lbs.—Syracuse, deflection	1–8	5–8	1 3–8	2 1–4	broke.						
2	Rail 5 ins. high, 69½ lbs.—Rome............	3–16	5–8	1 3–16	2	3 1–16	4 3–8	6	broke.			
3	Rail 4½ ins. high—Syracuse	1–8	9–16	1 1–4	2 1–4	3 5–8	5 1–4	broke.				
4	Rail 4½ ins. high—Funcke & Elbers' puddled steel, with iron flanges............	1–8	5–8	1 1–4	2 1–8	3 3–8	5 1–16	6 7–8	7 7–8	11 3–8	broke.	At 9th blow flange broke.
5	Rail 4½ ins. high—Funcke & Elbers' quality-iron rail	3–16	5–8	1 1–4	2 3–16	3 7–16	5	7	......	broke.	......	At 8th blow head broke sideways.
6	Rail 4½ ins. high—Pet-in Gaudet Bessemer steel..............	1–16	3–8	3–4	1 1–4	1 3–4	2 1–2	3 5–16	......	broke	......	in 3 pieces. At 8th blow broke both flanges at the bearings.
7	Rail 4½ ins. high—Manchester Bessemer, marked "section 27".	1–8	1–2	7–8	broke.							
8	Rail 4½ ins. high—Funcke & Elbers' full-steel rail........	......	......	......	......	......	......	......	......	......	......	Broke at 1st blow at 15 ft. elevation of drop.
9	Rail 4½ ins. high—Pet-in Gaudet Bessemer rail..............	......	......	......	......	......	......	......	......	......	......	Broke at 1st blow at 10 ft elevation of drop.

about 22¾ per cent. more strength or resistance against rupture, than the 4½ in. rails, and about 40 per cent. more strength than 4 in. rails. Judging from appearance of fracture, the No. 1 and 2 rails were made of cold-short re-rolled iron; No. 3 rail—fibrous base and part of head fibrous, and No. 5, "quality iron," hammered, vertically piled, cold-short head, base and steam fibrous and fine-grained.

The poor result of No. 7 test I consider an exception, as it is well known that Bessemer rails, of almost any make, will, in the average, show good results under the drop-test. The only remarkable result is, that the No. 6 and No. 12 Bessemer rails,

after showing great toughness, broke finally into three pieces, *which no good iron rail* can be made to do under similar circumstances.

Though rail-tests by heavy drops are very instructive (especially when the temperature at the time of testing is taken into account), and answer the purpose of testing the quality of iron rails and *welded* steel rails, I think that they are of little value for determining the practical strength of Bessemer or cast-steel ingot rails, which are much more affected by *vibration* than the former—*i. e.*, a rail piece under the drop is *inert* until the drop strikes it, whereas rails in the track (especially when fish-jointed, *are in violent vibration long before the approaching train passes over them.*

It is well known that ingot rails have

West Albany Locomotive Department, *February* 7, 1870.

Test of Rails by 2,240 lbs. drop. Bearings 3 feet apart. Signed F. J. Roth.
Temperature, 3.30 *P. M.*, 64 *deg. Fahrenheit. Commencing at elevation of 1 foot.*

Number.		DROP IN FEET.											
		1	2	3	4		6	7	8	9	10	11	
12	4½ ins. Dowlais, 12, 1869. Guest's steel, 67¾ lbs, New York Central standard section	1-8	9-16	1-8	1 3-4	2 7-16	3 5-16	4 3-8	5 11-16	7 1-16	7 3-4	broke.	In 3 pieces. At 10th blow bent sideways.

Commencing at 10 ft. Drop.

Number.		DROP IN FEET.					
		10	11	12	13	14	
10	4½ ins. Funcke & Elbers' 66 4-10 lbs. puddled steel rail, foot and part of stem fibrous iron, deflection....	3 1-4	6 7-8	10 1-2	broke.		
11	Funcke & Elbers', all steel, 66 8-10 lbs...	2 3-8	4 7-8	12	17	broke.	At 13 feet drop bent partly sideways showing small fractures; bent at right angles; had to be turned to break it.

been broken in the track into three pieces, when their outside as well as the fracture surfaces appeared entirely free from flaws or other defects. These broken pieces could subsequently not be broken under a 1 ton drop at 20 ft. elevation.

Question: Can ingot rails—which, on account of improper heating, retain an inner tension or unequal strain, after being rolled out and cooled—*break* merely on account of vibration? Similar results occur occasionally with cast bells.

Alexander Elbers.

Railways of the Colony of Victoria.—A return of the revenue and expenditure of the Victorian Railways for the half year ending the 30th of June, has been laid before Parliament by the Commissioner of Railways. The total train mileage is set down at 549,969 miles. The expenditure was £116,759 6s. 1d., including as items, £22,016 for maintenance of permanent way and works, £39,771 for locomotive charges, £47,146 for traffic charges, and £6,725 for general charges. The revenue during the same half year is stated at £279,117 17s. 11d.; of this, £114,060 was made up of the following items: Passengers (497,335½), £100,049; parcels, £5,592; horses, carriages, and dogs, £2,235; mails, £3,091; rents, £2,441, and gold escort, £650. The remaining £165,057 was made up of other items, such as goods (202,300 tons), £155,307; live stock (17,309), £9,749. A balance of £162,358 11s. 10d. was left in favor of the revenue.—*Engineering.*

INTERNATIONAL COMMUNICATION.

From "Engineering."

In the midst of all the numerous schemes, more or less chimerical, for meeting that requirement now allowed on all sides to be an absolute necessity, the proposition of Mr. John Fowler, Mr. Abernethy, and Mr. Wilson, has gradually taken a more and more prominent position, until it is recognized as the one means whereby the present inconvenience attending the Channel transit may be avoided, at all events, until the advancement of engineering skill and enterprise has pointed out a more efficient way, and proved by actual construction all that may be claimed for it, and which shall supersede the large boats, and ample accommodation Mr. Fowler provides, by accommodation more ample and transit more convenient and more rapid. Such schemes, despite the fact that some of them have been considered and advocated by engineers as able and responsible as those connected with the Channel ferry, must needs give precedence to that of Mr. Fowler. There is nothing problematical about his proposition, nothing uncertain. The difficulties to be encountered are on the surface, they can be accurately estimated and provided against, and the only element of doubt is the degree of commercial success which will ultimately attend the enterprise.

But although the opinion of efficient engineers, even of those who have put forward less certain, if bolder schemes, substantiate the views taken by the promoters of the channel ferry scheme, a number of incompetent objectors exist, whose adverse opinions possess sufficient weight to create much prejudice against the project. Nearly all the objections urged by this class of persons are comprised in a letter, which recently appeared in a daily paper, from a representative of these non-competents, and displays that lack of knowledge upon the details of the scheme he professes to criticise, which amply accounts for the errors into which the writer has fallen.

It is urged that, because the Great Eastern has proved unprofitable as a passenger ship, therefore large ferry boats plying between the English and French coasts must be also commercial failures; that the top weight produced by the presence of a train of carriages on deck would inevitably cause excessive rolling; that the difference of gauge between the French and English railways would prevent the interchange and working of stock on both sides of the Channel; that the harbor site selected on the French side is 8 miles removed from railway communication; and that, besides the want of judgment shown in selecting such a point as Andrescelles for the French terminus, the vast cost of making the harbor, assuredly much underestimated by the engineers, and the time required for their construction, would fatally interfere with the prospects of such an undertaking as a Channel ferry. Such, in brief, are the chief objections urged against this scheme, easily answered, but the impression produced by which it is not easy to remove.

It is difficult to understand why, because a sea-going ship, of upwards of 20,000 tons burthen, proved a failure as a passenger ship working 3,000-mile journeys, a ferry boat of 7,000 tons should necessarily work unprofitably upon a course of 20 miles with a constant stream of traffic flowing to and fro. As absurd is the argument, that the weight of the carriages on deck will induce rolling. Those objectors who so freely illustrate their case by quoting the Great Eastern, appear unable to realize the fact that the weight of 120 tons on the deck of a boat of 7,000 tons capacity would produce no appreciable result. In their mind's eye the deck of such a vessel appears crowded with railway carriages (to the exclusion of space for other accommodation), which would fearfully hamper the ship and inconvenience the passengers; instead of which the width of such a train would not be one quarter that of the boat. With regard to the alleged difference of gauge urged as existing upon English and French lines, it may be sufficient to state that both railways are of the same width precisely.

It is somewhat bold to challenge the judgment of three able engineers, by whom Andrescelles has been selected as the most suitable spot for a French landing place, and also to throw discredit upon

the estimates which have been carefully worked out and revised during the past few years. Besides the natural advantages offered by Andrescelles as a harbor, and they are great, its position with regard to Paris, will, when the few miles of railway are made that will connect the port with the main line, give those passengers who select the Dover and Calais route a considerable advantage in respect to time and distance, without materially interfering with the routes to the north of France and Belgium.

To all who are really able to appreciate the requirements for working the Channel traffic, it is apparent that it can (at present, at least) be only effected as proposed by Mr. Fowler, and, though the expense of constructing the necessary harbors on both sides will be great, and a considerable delay must be incurred before the new route can be opened to the public, it is at least gratifying to know that this means of international communication has emerged from the vague region of mere projects, and developed into an undertaking of which the foundation is now securely laid.

INDIAN FIELD ARTILLERY.

From "Engineering."

The special committee appointed to investigate the question of field artillery, has recently issued its report, which recommends material alteration in the equipment of that branch of the Indian service. The first great change recommended is the substitution of muzzle-loading rifle guns for the Armstrong breech-loaders. These latter, efficient and reliable, as a long experience has proved them to be, have also been proved by the same experience to be too complicated in their arrangement for easy manipulation in practice, and the resolution of the committee recommending the return to muzzle loaders will meet with general favor throughout the artillery service, which was largely represented by witnesses examined by the committee, and who were unanimous in giving their opinion that, under all circumstances, it was desirable to introduce muzzle-loading field guns into the Indian service.

In material, also, an important alteration has been suggested for adoption, and, despite the well-known reliability of iron, and the numerous objections raised against the use of bronze, such as its deficiency in durability, its softness, and its liability to rapid scoring, deterioration, and even melting under a rapid and sustained fire, bronze has been recommended by the committee as the material to be adopted in the future construction of light artillery.

This conclusion was not arrived at without a due consideration of the objections urged against the advocates of iron and steel, and an exhaustive series of trials were carried out to prove how far bronze could be relied upon, and the result of these experiments has fully justified the committee in their resolution.

The question of durability was decided by firing from two experimental guns, in one case 2,673 and in another 1,362 rounds without failure, a test "equivalent to a duration of about fifty-three and twenty-seven years of ordinary service," respectively. The capability of the metal to resist the effect of rapid firing was then proved by a rapid succession of 50 and 140 rounds at the rate of some 3 rounds per minute, and the other objections urged, such as rapid scoring, wearing away of the grooves, and honeycombing of the metal, were likewise answered by these and other tests, and it was shown with tolerable certainty that although undoubtedly there was a considerable wear of the grooves, it was confined to the loading sides, and not to the bearing sides of the grooves.

Altogether four classes of bronze guns were experimented upon by the committee, each of them 9-pounders, with 3 grooves, the twist of which was 1 in 30 diameters, the depth 11 in., and the width 8 in. Two weights, 6 cwt. and 8 cwt., were employed, and two classes of rifling, the Woolwich system, and an adaptation of the French plan, which last was ultimately recommended in conjunction with the heavier piece, which gave better results, in accuracy, extent of range, and could also, if necessity demanded, be employed as a 12-pounder.

The ammunition recommended for this

new weapon consists of common shell, case shot, and shrapnel, provided with Boxer's wood time fuses, set to nine and five seconds. An efficient percussion fuse is also recommended, if such can be designed; in which case the proportion of different projectiles would be considerably altered. At present, segment shell, it is suggested, should form no part of the equipment, which should consist of more than one-half shrapnel. A charge of 1 lb. 12 oz. is recommended, and a bursting charge of $7\frac{1}{2}$ oz. for the common shell.

Wrought-iron carriages have been recommended for every reason, in preference to steel or wooden ones, and the experimental carriages employed by the committee have withstood a test of 3,746 rounds in one case, and 3,360 rounds in the other, with but small injuries. Important modifications have been introduced into the pattern of carriage suggested, by which the gunners, working the battery, can be brought up with their guns; the ammunition boxes have been re-arranged, and the elevating screw has been designed in the simplest possible manner, and consists of a screw passing through a nut upon brackets on the carriage, and driven by gearing and a handle outside the bracket.

Important improvements have also been made in the design of the wagons attached to the battery.

The following are the particulars of dimensions and weight of the new guns and wagons;

Nine-pounder Gun, 3 in. Bore, French Rifling.

	cwt.	qrs.	lbs.	
Actual weight	8	0	12	
Breach preponderance		......		7 lb.
Bore — Diameter		......		3 in.
Bore — Length		......		63.5 in
Grooves — Number		......		3
Grooves — Width		......		11 in. at top, 8 in. at bottom
Twist uniform,	one	turn	in	90 in.
Length of rifling		......		59.8 in.
" gun over all		......		72.0 in.
Weight of gun carriage	10	2	0	
" limber	10	0	0	
" ammunition and stores	4	0	9	
Total weight	32	2	12	

The total weight of wagon will be $32\frac{3}{4}$ cwt., including 90 rounds of ammunition. This number, together with that carried on the gun itself, increases the total number of rounds per battery to 124.

WHEELER'S STEEL-IRON PROCESS.

From "The United States Railroad and Mining Register."

Notwithstanding the great progress made of late years in the cheap production of steel, and the consequent largely increased use of this material, it is a fact not to be controverted that steel alone does not, and cannot fulfil all the conditions which are inevitably imposed upon any material subjected to the almost universal applications required by our great mechanical and railroad interests.

This failure is not due to the steel itself, but rather, we think, to a misapplication of it—to placing it in a position for which it is not adapted by nature, and, as it were, forcing it to do work, and to bear load and strain, for which it was never intended.

"The conclusion at which I have long since arrived," says Sir Wm. Armstrong, "and which I still maintain, is, that although steel has much greater tensile strength than wrought-iron, it is less adapted to resist concussive strain. * * * It is impossible that I can hold any other opinion than that the vibratory action attending accessive concussion is more dangerous to steel than to iron."

Here then is the rock on which the too enthusiastic advocates of steel have fallen. Because steel could be produced cheaply, they have endeavored to supplant iron with it, overlooking, for the time, the fact that steel could not be both steel and iron; and, therefore, it should not have been subjected to conditions which required for success that it should possess the desirable qualities of each.

Experience is a good teacher, but charges abominably high prices, says Carlyle, and though the disappointment of steel makers and of steel users has been attended with no little expense, the

experience gained has been valuable, and is leading in a direction where we shall be able to secure and render available the well-known desirable properties of steel, without incurring the dangers of its treachery when employed alone.

For some time the attention of practical men has been attracted to the great desirability of so combining large masses of iron and steel, as to secure the tenacity of the one with the durability of the other. Every mechanic is familiar with combined iron and steel and its constant and successful use where steel alone will not stand at all; but the difficulty in thoroughly uniting two such dissimilar metals, involving the use of expensive fluxes, hand labor, and the most skilful manipulation, has hitherto precluded its use except for special purposes, and has, therefore, made its cost double and treble that of all steel.

The numerous attempts that have been made to make a steel-headed iron rail, show conclusively the desire of our railroads to secure the two important elements of strength and wear; but the difficulty in attaining this desideratum has been the impracticability of uniformly securing such a union of iron and steel as would stand the tremendous tests of weight and speed, and also to make the union so cheaply as to afford the rail at a reasonable price.

Every blacksmith knows full well the danger of "burning" steel when heating it to a welding point, and this risk is immensely increased when the mass is augmented as for a "rail pile," and subjected to the intense heat of a furnace; if fluxes and steam-hammers are employed to perfect a union of "high" steel and iron, the cost of the operation is too much enhanced to be remunerative, while, an the other hand, if "low" steel, which will stand heat, is used, the resulting rail head is scarcely, if any, better than iron.

These apparently insurmountable obstacles have thus far been the one great difficulty in the way of successfully and cheaply combining iron and steel in such masses and proportions as would make the combination available for such extended purposes as are required by the great railroad and mechanical interests; but it is too much to say, in this age, that a thing cannot be done because previous attempts have failed, and we often find that means the most simple, and overlooked because of their simplicity, are amply adequate to produce a long-desired result.

We have within a few days seen and examined a process for uniting iron and steel, discovered by Mr. E. Wheeler, of Philadelphia (late of Boston), which, from its extreme simplicity and certainty, seems to fill all the conditions for working the two metals into successful combinations for any and all purposes. Mr. Wheeler has for many years been a practical iron manipulator, and has for some time been engaged in extensive experiments to combine iron and steel. Starting with the theory that there is no difficulty in uniting the two, providing that the steel is brought to a "welding heat" simultaneously with the iron, and that the steel, while being so heated, cannot suffer injury or "burning," if kept from the direct action of the flame and oxygen (as when melted in a crucible), he reduces it to practice by the ingenious and simple device of completely encasing the steel with iron during the entire process of heating and reduction. The steel being thus not merely covered, but encased, is effectually protected from the decarbonizing effects of excessive heat, and can be safely heated to a perfect welding state in the usual iron furnaces without flux of any kind, and in this condition may be rolled down and manipulated as readily, and at the same speed, as iron, in ordinary rolls.

Simple as this method is (and its simplicity is its great value), it accomplishes the most important results. We have seen the highest grade of cast tool steel, thus enclosed, and filled with iron, subjected to the intense heat of a heating furnace, and then rolled down into bars at the rate of 500 ft. per minute, and the steel, though perfectly welded to the iron, presented the same bright, clean fracture when broken as in the original state, and would harden as readily in a water bath.

Mr. Wheeler showed us a car axle rolled by his process at one heat, at the Pencoyd Works, of this city, consisting of a core of iron surrounded by a tube of steel, and both in turn by a shell of iron, the whole being as solid and perfect as a homogeneous mass of iron. This plan gives a steel journal, while the iron core and shell secures strength and prevents fracture or breakage of the steel.

The practical uses to which this cheap and effectual method of welding iron and steel can be applied are innumerable. By it any grade or kind of steel may be used, from Bessemer or "puddled" to crucible, and it can be united to iron in any shape or proportion. Mr. W. is already making combination in merchant bar forms, at the works of Messrs. Marshall, Phillips & Co., 24 Girard avenue, Philadelphia, for set screws with steel centre, horse-shoe bars with steel face, carriage tire with steel corners, etc., etc., and we learn that several prominent rail manufacturers are about to apply this process to the making of steel-headed rails, for which it appears peculiarly adapted.

Another very important application of the invention is to the reduction of steel ingots and the reworking of steel bars or scrap. Hitherto immense steam-hammers have been found indispensable to condense the ingot, or compact the pile, and make the steel homogeneous and sound, from the fact that, owing to the impracticability of heating exposed steel above a "cherry red" without injury, only immense force could compress the particles, and render the mass uniform. By Mr. W.'s method of encasing the ingot or pile in iron, he makes heat do the work of applied force, and by thus safely heating the steel to a soft state is enabled to condense and compact it with a comparatively slight expenditure of power by means of ordinary rolls.

TUNNELS OF THE PACIFIC RAILROAD.

Abstract of a Paper read before the American Society of Engineers, Jan. 5, 1870, by John R. Gilliss, Civil Engineer, Member of the Society.

During the past summer the track has been completed across this continent, and so much sooner than was thought possible, that the difficulties overcome are apt to be underrated. Some account of a single item in the great work may therefore be interesting.

Between Omaha and Sacramento there are nineteen tunnels. Four of these are on the Union Pacific and fifteen on the Central.

Central Pacific Tunnels.—The tunnels of the Central Pacific are nearly all near the summit, where it crosses the western range of the Sierra Nevada. The line here lies on steep hill-sides, in some cases being, for long distances, on a face of bare granite, more or less broken by projecting ledges and boulders, but with an average slope often greater than 1 to 1. In such places embankments were almost impracticable; the hills were too steep to catch the slopes, and most of the rock from cuts was thrown far down hill by heavy seam blasts. On these accounts the line, for two miles east of Donner Pass, was thrown further into the hill than on original location, thus adding to the depths of cuttings and increasing the number of tunnels, but saving retaining walls, and where tunnels were made, enabling the work to be carried on in winter. Another important object was the saving of snow-covering where tunnels were made, and giving a good foundation for it where they were not. It is within these two miles that seven tunnels are crowded.

Tunnels 1 and 2 are both west of Cisco, a small track 92 miles from Sacramento, and within 13 of the summit. They were both finished in 1866. During the fall of that year the track reached Cisco, and as fast as the gangs of Chinamen were released they were hurried to the summit to be distributed among the tunnels in its vicinity. The year before, some gangs had been sent to summit tunnel No. 6, and commenced the cuts at its extremities; winter set in before the headings were started, and the work had to be abandoned. To avoid a repetition of such delay, the approaches to all the tunnels were covered with men, and worked night and day in three shifts of eight hours each. Thus time was saved, and the tunnel organization started at once. As an illustration of the hurry, I may mention walking two miles over the hills after dark, and staking out the east end of No. 12 by the light of a bonfire; at 9 o'clock the men were at work.

In November and the early part of December there were several snow-storms, just enough to stimulate without delaying the work. The rough rocky sides of Don-

ner Peak soon became smooth, slopes of snow and ice covering the trail that led from tunnel 8 to 9; it remained impassable until spring, and communication had to be kept up by the wagon-road, five or six hundred feet below. This, the Dutch Flat and Donner Lake wagon road, was opened soon after it was decided to adopt this route. From the Pass the descent toward the lake was over very rough ground, requiring heavy side cuts and retaining walls with numerous zigzags to gain distance.

From this road the scene was strangely beautiful at night. The tall firs, though drooping under their heavy burdens, pointed to the mountains that overhung them, where the fires that lit seven tunnels shone like stars on their snowy sides. The only sound that came down to break the stillness of the winter night was the sharp ring of hammer on steel, or the heavy reports of the blasts.

Winter of 1866–7.—By the time winter had set in fairly the headings were all under ground. The work was then independent of weather, except as storms would block up tunnel entrances, or avalanches sweep over the shanties of the laborers. Before tracing the progress of the work underground, it will be well to see the character of weather out-doors.

A set of meteorological instruments was furnished by Colonel Williamson, of the United States Engineers, consisting of barometer, wet, dry, maximum and minimum thermometers. These, with wind, clouds, etc., were recorded three times a day, and hourly during ten days in each month. From this record the table of storms given in Appendix C was made.

Snow-storms.—These storms, 44 in number, varied in length from a short snow squall to a two-week gale, and in depth from ¼ in. to 10 ft.—none less than the former number being recorded, nor had we occasion to note any greater than the latter. This, the heaviest storm of the winter, began February 18th, at 2 P. M., and snowed steadily until 10 P. M. of the 22d, during which time 6 ft. fell. The supply of raw material was then exhausted, but the barometer kept low and the wind heavy from the south-west for five days more, by which time a fresh supply of damp air came up from the Pacific, and then, as the machinery was still running full speed, this was ground up without delay. It snowed steadily until March 2d, making 10 ft. snow and 13 days' storm. It is true that no snow fell for 5 days, but it drifted so furiously during that time that the snow-tunnel at east end of tunnel No. 6 had to be lengthened 50 ft.

These storms were grand. They always began with a fall in the barometer, and a strong wind from the south-west, hurrying up the tattered rain-clouds or storm-scud in heavy masses. The barometer, which averaged 23 in., would drop sometimes as low as 22½. The thermometer was rarely below 20 deg. at the beginning of a storm, and usually rose to 32 deg. before its close, so that the last snow would be damp and heavy, sometimes ending in rain. The storms ended, and clouds were scattered by cold winds blowing over the eastern range of the Sierra Nevada; these raised the barometer and dropped the temperature at once. The lowest temperature of the winter was from a wind of this sort, 5½ deg. above zero.

Our quarters were at the east end of Donner Pass, but still in the narrow part. About the second or third day of a storm the wind would be a gale, sometimes 10 lbs. to a square foot; and would plough up the new-fallen snow to heap it in huge drifts beyond the east end of the pass. About 30 ft. from our windows was a large warehouse; this was often hidden completely by the furious torrent of almost solid snow that swept through the gorge. On the cliff above, the cedar trees are deeply cut, many branches of the thickness of a man's wrist being taken off entirely by the drifting snow-flakes.

No one can face these storms when they are in earnest. Three of our party came through the pass one evening, walking with the storm—two got in safely. After waiting a while, just as we were starting out to look up the third, he came in exhausted. In a short, straight path, between two walls of rock, he had lost his way and thought his last hour had come.

Snow-tunnels.—Before the snow had acquired depth enough to interfere much with the work, the headings were all started. The cuts at their entrances soon filled up with snow, but drifts were run through them, in some instances large enough for a two-horse team. Through these snow-tunnels, whose lengths varied from 50 to 200 ft., the ma-

terial excavated was hauled in carts or on sleds to the waste banks. These snow-tunnels kept settling at the crown, so that they had to be enlarged from time to time, otherwise they were perfectly satisfactory.

The most remarkable snow-tunnel was made to connect the two ends of tunnel 8. The spur through which this is made terminates in a vertical bluff of granite 100 ft. high. To get around it during the fall, a rope was fastened to the rocks at a point where there was a steep descent of 30 or 40 ft. During the early part of winter, a snow-drift formed on the face of this bluff, descending in a deep slope from its top to the wagon road, 200 ft. below. On this slope a trail was cut and used for a month or two.

Later in the winter, when the accumulation of snow made it practicable, a snow-tunnel was excavated through the drift, and around the face of the bluff. Windows were made at short intervals for light, and to throw the material out in excavating, and steps cut where a descent was necessary. One flight of these led down to the blacksmith's shop, buried still deeper in the snow, while the main passage led into one already excavated at the east end of tunnel 8. The snow kept settling down hill and away from the bluff, so that there was an open space of 3 or 4 ft. between it and the rock towards the close, which was far from inspiring much confidence in the route.

Between tunnels 7 and 8 there is a deep ravine, in crossing which the road has a 4x5-ft. box culvert, and a retaining wall on the lower side at 75 ft. extreme height. The foundation was begun in fall, but stopped by winter, and the ravine filled with snow. Next spring a snow-tunnel was commenced about 200 ft. down the ravine, and run in to strike the unfinished foundation. Smaller tunnels were run to quarry stone got out in fall, and a cave dug over the foundation large enough to work in. The culvert was built, and by the time it was finished the depth of snow overhead had decreased to 25 or 30 ft.; this was excavated by a stream of water, and the retaining wall commenced.

Snow-cuts.—In spring, when the road has begun to be bare, so that sleighs can no longer be used, there are very heavy banks of snow to cut through to make the road passable for wagons.

In June I measured one of these cuts through the end of a snow-slide, and found it 25 ft. deep. A week later the road was dusty in the centre, but the snow-banks were not all gone until July, so that we had at that place the strange spectacle of sprinkling-wagons watering a road between two walls of solid snow

Alignment.—As soon as each heading became sufficiently advanced, the centre line was secured, generally by small holes drilled in the roof, with wooden plugs and tacks. These points were placed as far apart as length excavated would permit, and from them the line produced as the work advanced. In most cases the entrances were afterwards so blocked up with snow that it was impossible to recur to the line outside, and the tunnels were completed from the points first put in.

In running lines outside during the winter, it was generally necessary to make deep cuts, and sometimes tunnels, through the snow, to get at the original transit points.

Most of the tunnels are on curves, No. 13 being on one of 573 ft. radius, with 87 deg. of curvature inside the tunnel. In this, as in No. 11, the usual difficulties of working with instruments by candle-light were much increased by the numerous temporary timbers in the headings. The lines met in the centre of the tunnel, parallel to each other, but 2 in. apart. In the other cases the discrepancies were too slight to notice.

Dimensions.—Most of the work was through solid rock, which did not require lining, and the following dimensions were adopted: Bottom, a rectangle, 16x11 ft.; arch, a semi-circle, 16 ft. in diameter; grade at centre of tie, and 1 ft. 3 in. above sub-grade.

Tunnel 11 was partly, and tunnel 13 wholly, lined with timber in the following manner: 12″x12″ sills were placed on each side, and posts 12′x16″ mortised into them. The latter support arches, each composed of 3 thicknesses of 5″x12″ plank, breaking joints, and bolted with ¾-in. iron bolts, thus making a solid arch of 180 square in. sectional area. The distance from centre to centre of arches varies from 1½ ft. to 5 ft., according to material. Over the arches, and, where the material required it, on the sides, also, split lagging about 2½ in. thick was put in. The width at sub-grade inside of

posts is 17 ft.; at springing line inside of arches, 19 ft.; giving a batter of 1 ft. on each side. Height of crown above grade, 10 ft. 9 in., thus leaving room for masonry inside the temporary wooden lining.

Tunnels 1 and 2 were lined in a similar manner, except that the batter of side posts were only 6 in.

In these tunnels, through soft material, the heading was supported by temporary timbers. Chambers were then excavated at the sides to below sub-grade, for the sills, and the central core left to support the shores which held the material above in place. As the timbering advanced, the core and false work were removed.

In tunnel No. 12, a short distance in the centre was found to be decomposed granite, and after the tunnel was excavated a light set of timbers was put in. They consisted of arches, each composed of 7 pieces of 10x19 in. timber, with side posts and sills similar to those already described.

In all the tunnels on curves, allowance was made for elevation of outer rail, so that top of cars would remain in centre of opening.

Laborers.—With the exception of a few white men at the west end of tunnel No. 6, the laboring force was entirely composed of Chinamen, with white foremen —the laborers working usually in 3 shifts of 8 hours each, and the foremen in 2 shifts of 12 hours each. A single foreman, with a gang of 30 to 40 men, generally constituted the force at work at each end of a tunnel; of these, 12 to 15 worked on the heading, and the rest on bottom, removing material, etc.

When a gang was small, or the men needed elsewhere, the bottoms were worked with fewer men, or stopped so as to keep the headings going.

The Chinamen were as as steady, hard-working a set of men as could be found. They were paid from $30 to $35, in gold, a month, finding themselves; while the white men were paid about the same, but with their board thrown in. The force at work on the road probably averaged from 6,000 to 10,000, nine-tenths of them being Chinamen.

Tunnel No. 6.—This, the longest tunnel of the road, is parallel to, and about 400 ft. north of Donner Pass. Its length is 1,659 ft., and greatest depth below the surface 124 ft., measuring from grade. The material is granite, of a medium quality, crossed by seams in every direction.

To expedite the work a shaft was sunk about the middle of the tunnel, its dimensions being 8x12x72.9 ft.

Work was commenced on the shaft August 27th, and for the first 30 ft. it was sunk at the rate of a foot a day, after which its progress slackened, from delay in hoisting the material with a common hand derrick.

Meanwhile a house was being built over the shaft, and the hoisting engine was put up. The latter consisted of an old locomotive, the Sacramento, and, by an interesting coincidence, the first engine run in the State. This was geared to a drum 6 ft. in diameter. The house was 50 ft square, containing in addition to the hoisting apparatus, forges, fuel, tamping, etc., so that when snowed in, these articles would be close at hand. The shaft was divided by planking into two compartments, each 5 ft. square; over these were two "jiggers" or transfer tables. The buckets were first of wood, then two additional ones were made of boiler plate, 4 ft. 9 in. square by 2 ft. 6 in. high, outside dimensions, and fitted for side dumping. They were loaded at the face of the work below, run on trucks to the bottom of the shaft, hoisted and transferred to other trucks to run out on the waste bank.

Total days' work on shaft, 85; average progress, 0.85 ft. in 24 hours. Nitro-glycerine had not yet been introduced; with it the progress would probably have averaged 1.5 ft.

Nytro-Glycerine—This was introduced on the work early in 1867, to expedite progress of the summit tunnel. It was made on the spot by Mr. James Howden, and used in the four headings of tunnel No. 6 from Feb. 9th, and to some extent in tunnel No. 8, but not enough to give data for comparison. After the headings of these tunnels were through, it was used in the bottoms.

In the headings of summit tunnel the average daily progress with powder was 1.18 ft. per day with nitro-glycerine, 1.82 ft., or over 54 per cent. additional progress.

In bottom of summit tunnel, average daily progress with powder, full gangs, was 2.51 ft.; with nytro-glycerine, 4.38, or over 74 per cent. in favor of nitro-

glycerine. The same number of men were used with both explosives.

The conclusion we may safely come to from the Central Pacific work, is, that in hard rock tunnels, with the same number of men, over fifty per cent. additional progress can be made by using nitro-glycerine in place of powder, and the expense will be reduced proportionately.

Tunnels of the Union Pacific Railroad.—Tunnel No. 1 is on St. Mary's Creek, about 680 miles west from Omaha, and 12 miles east of second crossing of North Platte River. It was commenced April 30, 1868, and continued from each end until June 8. At that time the two headings were in 86 and 87 ft. respectively, the progress having averaged 2.22 ft. per day. A soft spot was then found in the west end, and there being no means of lining without delay, the open cut was extended to cover the place, and the length of tunnel reduced to 215 ft.

This delayed the work, so that a temporary track had to be built around it.

Tunnel No. 2 is at the head of Echo Cañon, in Utah, about 972 miles from Omaha. Its length is 772.3 ft., being the longest of the Union Pacific. The approaches were started in July, 1868; they are heavy cuts through clay. Rock was struck about the end of August, and found to be like the prevailing formation in the vicinity, an indurated clay, with occasional streaks of soft sandstone. Most of it drilled very easily, but required as much powder in blasting as ordinary rock. While damp it stood firm, but after sufficient exposure to the air to dry out the moisture, it cracked and crumbled like lime in slacking. These qualities made the work very expensive; rock prices had to be paid, and earth slopes taken out.

In starting the headings they had to be supported the same day the excavation was made; but on getting fairly in, the roof would stand well a week or two.

There was an irregular streak of blue sandstone which ran completely through the tunnel near the springing line.

The headings were started at the west end, August 29, and at the east end, September 5; they met January 30, 1869. The tunnel was finished April 3, 1869.

When work was commenced on the tunnel, the track was still 300 miles east, and all the available transportation required to haul tools, materials, and provisions over this gap; it was useless even to think of getting cement in time. There was no suitable stone near the work, and the clay had too much lime to make brick. On these accounts the tunnel had to be lined with timber.

Tunnel No. 3.—This tunnel is through a sharp spur of black limestone and dark blue quartzite, 266 ft. of the former and 242 ft. of the latter, total length 508 ft., on a 3 deg. 30 min. curve to the left. The headings were commenced about September 1, 1868, and met April 4, 1869. Until December 27th the work was part of Brigham Young's contract, and sublet to Sharp & Young. It was then carried on as company work, and let to Daniel McGee, a "Gentile," February 9th. Not being finished in time for the rails, a temporary track was built around it, partly on a 22 deg. curve, 260 ft. radius, around which trains of 23 cars were taken.

Nitro-glycerine was fairly introduced into the tunnel by February 23d. About 20 per cent. of the tunnel men struck on account of its use, and were not replaced, as two shifts on the bottoms were found enough to keep them up with the headings, notwithstanding the additional progress they too were making; three shifts had been required with powder. About twice as much work was done per man with nitro-glycerine as with powder. The use of nitro-glycerine in tunnel No. 3 saved the company nearly $40,000.

Tunnel No. 4.—Length 297 ft.; alignement 4 deg. to left; material, quartzite, similar to that in tunnel No. 3. Headings were commenced about September 10, 1868, and tunnel finished January 29th; nitro-glycerine was used to take up the last 180 ft. of bottom, which it did in 11 days; making the remarkable progress of 8.18 ft. per day from each end. In tunnel No. 4, 1,960 cubic yards were taken out with powder, requiring 289 kegs and 7,000 ft. of fuse, or $3\frac{7}{10}$ lbs. powder and $3\frac{6}{10}$ ft. fuze per cubic yard.

Comparison between the two roads.—The total length of tunnelling on the Central Pacific is 6,213 ft.; on the Union, 1,792. The cross sections of tunnels on the two roads are practically identical.

The circumstances and materials varied too much to make an accurate comparison of progress in tunnels of the two roads. The greatest average daily prog-

ress of heading on the Central Pacific, through granite with nitro-glycerine, was 3.29 ft. On the Union Pacific, through quartzite, about as hard as granite, 4.62 ft. Each road has done over 8 ft. per day at a single face in taking up bottom.

The laborers on the Central Pacific were mostly Chinamen, paid $30 to $35 gold per month, working three shifts per day in tunnels, and 12 to 15 men in a heading. On the Union Pacific the laborers were white men, paid $3 to $4 per day currency, generally working two shifts per day, and 8 to 12 men in a heading, on tunnels 1 and 2, and three shifts of 14 to 16 on tunnels 3 and 4.

The Central Pacific Railroad was built under the direction of S. S. Montague, Chief Engineer. The location and construction across the Sierra Nevada were in charge of L. M. Clements, Resident Engineer. The account of tunnels on that work is principally compiled from a report on the subject written for the latter by the author, while engaged on tunnels 6 to 13 of that work.

The Union Pacific Railroad was built, and its location revised, under the direction of S. B. Reed, Engineer and Superintendent of Construction. The accounts of tunnels 1 and 2 are from personal observation, and of tunnels 3 and 4 from data furnished by Edward P. North, Resident Engineer of work in Weber Cañon.

WROUGHT IRON AND STEEL.

THE FLUO-TITANIC PROCESS.

This process is a new discovery, and has for its object the production of wrought-iron and steel from crude cast-iron, by the use of fluxes, and without manual labor. The results obtained from experimental operations have been so certain and uniform as to leave no doubt of its success when applied on the largest scale of manufacture.

Wrought-iron is usually made from pig-iron, and it is the purest of the different sorts of iron produced metallurgically. It is often contaminated with substances chemically combined, such as sulphur, phosphorus, and silicon, or its carbon is unevenly distributed; all these circumstances modify the properties of the wrought-iron—strength, property of welding, hardness, etc.

The manipulations in the production of wrought-iron have been principally directed to removing as much as possible of the impurities contained in pig-iron, mainly by oxidation of most of the carbon; and in order to render the wrought-iron tractable, both at low and high temperatures, the foreign admixtures (sulphur, phosphorus, silicon, etc.) must at the same time be separated by oxidation, forming the volatile substances, whilst the fixed substances may be scorified.

The oxidizing agents are, chiefly, the oxygen of the atmosphere, and fluxes rich in oxygen, usually applied at the melting temperature (in fineries, reverberatory furnaces, or in the Bessemer converter). The puddling process, conducted in reverberatory furnaces, is in general use for the production of wrought-iron, and is about the only available method, until now, for making wrought-iron from pig-iron, in which sulphur and phosphorus are present. In Bessemer's process very grey pig-iron, almost wholly free from sulphur and phosphorus, is required. Bessemer conducts liquid iron from blast furnaces into special apparatus, in which he burns out the carbon by blast, and without the application of fuel. The temperature thus produced, together with that of the burning and liquid iron, is sufficiently high to liquify even malleable iron. In this process it is very difficult to separate the carbon to the required limit, when employing a very pure iron, on which account a friable burnt iron, poor in carbon, is likely to result; and this iron will be red and cold-short at the same time, when treating impure cast-iron, as phosphorus and sulphur cannot be sufficiently extracted, owing to the rapidity of the operation. This circumstance, and the great loss of iron, are the reasons why this method has not been generally introduced; but it is applied in the manufacture of steel, when it is more easy to fix the point of decarbonization.

Consequently, there has been the want of a process that is economical as to cost of production, and certain as to results,

that will produce superior qualities of wrought-iron and steel from pig-irons that are too poor for the Bessemer process (and which comprise over 90 per cent. of the pig-iron produced), and from which better results are to be obtained than by puddling; and that, at the same time, will do away with the waste attending the other processes, and without the manual labor of puddling.

All of these conditions are fulfilled in the new fluo-titanic process; which consists, as its name implies, in the combined use of fluor-spar and titaniferous iron ores with liquid cast-iron, for removing carbon, silicon, sulphur, and phosphorus. This process differs from other processes in the respect that it is reducing as well as oxidizing, and is not attended with the waste of the other methods; on the contrary, the iron in the titaniferous ore is rendered metallic by the reactions of the oxygen in the ore with the carbon in the pig-iron.

Several modes of application have been tried with success. In one, granulated cast-iron was charged into a furnace in admixture with titaniferous iron ore and fluor-spar, both pulverized. When the iron melted, the heat dissolved the fluor-spar, which combined with the titanic acid in the iron ore; and, by reason of the affinities of these two substances for carbon, silicon, sulphur, and phosphorus, these substances were taken from the iron in the form of vapor and slag, leaving the resulting wrought-iron in the liquid state, to be run off into ingots to be hammered or rolled.

Another method of treatment is, to mix titanic iron ore with fluor-spar, applied at the bottom of a vessel or furnace and rendered plastic by means of heat or by mucilagenous substances; and to run the molten cast-iron in upon them. When titaniferous cast-iron is used, fluor-spar will only be required to produce the same result. The reactions between the fluor-spar and titanium with the carbon, silicon, sulphur, and phosphorus, are wholly spontaneous, and last from 20 to 30 minutes after the fluor-spar melts.

In order to produce steel of any required grade by this process, it is only necessary to vary the proportions of fluor-spar and titaniferous iron ore and the grade of the pig-iron. Owing to the quick reactions when using white iron, this iron is preferred when wrought-iron is required, and graphitic cast-iron when steel is wanted; in which case the proportions of fluor-spar and titanferous iron ore may be so graduated as to remove all of the silicon and other impurities, and leave just the required amount of carbon in the metal to form the grade of steel required, the carbon becoming chemically combined.

The fluo-titanic process is more economical with the same grades of pig-iron as compared with the Bessemer process, for producing steel, as there is no loss of weight; on the contrary, there is a slight gain over the weight of the pig-iron used, by the reduction of the iron in titaniferous ore to the metallic state, before referred to, which becomes incorporated with the product of conversion; whilst, by the Bessemer process, only about 78 per cent. (sometimes 80 per cent.) are produced from the pig-iron, 70 per cent. of which are pure ingots, and 8 per cent. are waste steel.

As compared with the puddling process, the fluo-titanic is as marked in economy and superiority of product as it is with the Bessemer process (as will be seen by the analyses of results obtained). Manual labor is unnecessary in the new process; and about one-half the fuel is required for the conversion, as compared with puddling. When the puddling process is conducted in the "dry" way, there is a loss of iron amounting from 8 to 10 per cent.; and when the "wet" or boiling system is used, about 45 per cent. of rich oxide of iron is required; and there is but little or no loss from the weight of the pig-iron charged. The items of waste by the "dry" method, and the use of oxides by the "wet" methods of puddling, about counterbalance each other as to cost of production; and are about equal to the cost of fluor-spar and titanic iron ore used in the new process, so that the net gain derivable from the use of the new process, over puddling, will be in the saving of the manual labor of puddling, and one-half of the fuel, and in the superior quality of the result, and in the increased production from the same investment of capital.

The proportion used of titaniferous iron ore is about 5 cwt. when containing 35 per cent. of titanic acid, 60 per cent. of oxide of iron, and small portions of

silica, manganese and magnesia, and 2 cwt. of fluor-spar to a ton of pig-iron.

In the experiments that have been made, the most inferior iron produced in large quantities was selected. It is well known in the trade, as the English Cleveland pig-iron. The specimen selected was white iron, produced by the irregular working of the blast furnace ; and it contained more impurities than if produced by the regular process. In the items of sulphur it was in excess of the published analyses of the grey pig-irons of that district. The analyses of the iron used, and of the resulting refined metal, are as follows :

PIG-IRON.

Combined Carbon	3.3710
Silicon	1.8139
Sulphur	0.3620
Phosphorus	1.3810
Iron by difference	93.0721
	100.0000

REFINED METAL.

Carbon	Traces
Silicon	None
Sulphur	0.0620
Phosphorus	0.1399
Titanium	0.0215
Iron by difference	99.7766
	100.0000

The above metal, when produced on a large scale, will be in the form of blooms or ingots ; and it is a fact well known to metallurgists that the subsequent working into bars or other required forms generally reduces the amounts of phosphorus and sulphur, each from 0.03 to 0.05 ; so that the refined bars produced by the new process will not contain more of these substances than the highest grades of wrought-iron produced, such as Low Moor and other brands that command the highest rates, and are in great request for engineering purposes, bringing higher prices than many kinds of steel. The amount of phosphorus in the foregoing analysis is less than Prof. Gruner, of the Ecole des Mines, reports in the Heaton cast-steel, which is produced at much greater cost.

From the foregoing it will be obvious to all practical iron workers that there are many grades of cast-iron that are too impure to be worked by the old method into best cast-steel, which will be made, by the new invention, available for this purpose.

In the "Engineer" of October 22d, of last year, is published a tabular statement prepared by Mr. D. Kirkaldy, showing the great ductility of iron produced from titaniferous ores, which had been rolled into boiler plates, bars, and other engineering work. The remarkable statement is there made that some of the bars were drawn as much as one-quarter of their length before breaking.

Titaniferous iron ore is generally considered in the United States as being of no use for the manufacture of pig-iron, and has not yet entered into the production of iron or steel, except experimentally. It is found in large quantities in the State of New York, of excellent quality ; and it bids fair to become one of the most useful ores of iron.

Fluor-spar is very abundant in Ohio, Indiana, and Illinois.

This process is the invention of James Henderson of 30 Broadway, New York, and has been patented in the United States and Europe.

ORDNANCE EXPERIMENTS.—At Fortress Monroe a new projectile has been lately tried, which the inventor, a citizen of Iowa, is anxious to get adopted by the Ordnance Department. The shot is conical, with a rifled bore inside. An 8-in. shot, with the inner bore unloaded, weighs about 200 lbs. A shot of this kind has a bore 3½ in. in diameter and 8 in. deep, which is loaded by ½ lb. of powder, a 12½-lbs. shot, and a brass plug in two pieces, which fits into the muzzle. Thus charged, the projectile is fired from an ordinary rifled cannon. The theory is, that after the projectile has almost spent itself, a time fuse will explode the charge inside, and the 12½-lbs. shot will be discharged as if from a cannon, the entire range thus accomplished being from 8 to 10 miles. At first the experiments were not successful, the plug and ball coming out before the projectile had travelled a mile. Afterwards the plug was screwed in, thus keeping the ball in position until the fuse burnt down to the powder. One paper suggests that the principle, if carried out, will make us invincible in a foreign war, as the gunners at Fortress Monroe will only have to get the true range to batter down the walls of Pekin. The "New York Herald" describes the projectile as a "gunpowder boomerang," and hopes the "first shot may always be so contrived as not to turn any somersaults, and so send the second shot the wrong way."

COUNTERBRACING.

By S. H. SHREVE, C. E.

Probably in the practice of foreign and American engineers, there is no point about which they differ more widely than that of counterbracing in bridges. Even among American engineers there is much variance and dispute as to the true purpose of counterbraces. To Mr. Haupt belongs the honor of first teaching that they were solely for stiffening the truss, and consequently should be of the same section from one end of the bridge to the other. This doctrine has many followers, even at the present day, but the more intelligent of our engineers have seen its fallacy, and in our best bridges, as now constructed, the counterbraces are proportioned to carry a part of an uneven load. Still, the effects of the early teaching on the subject are everywhere apparent in their proportions, and it is pertinaciously clung to as an American doctrine, that they must extend to the very end of a bridge.

It is the custom now, to calculate the strains upon a bridge under the maximum uniform load, and from them to proportion the main-braces and chords. Then the load is brought on, panel by panel, and the counterbraces are proportioned to carry a certain part of the weight to the farther abutment. This certainly gives all the strains that can come upon any member of the bridge; but it does more—it gives too much. The weight of the bridge itself should enter into every calculation, as well for the partial as for the maximum loads.

It is probably too self-evident to need proof, that in the same panel a main and a counterbrace cannot act at the same time. One only can act, and if the horizontal thrusts of the weights on either side the panel balance, neither of the braces act. If a truss be divided into an uneven number of panels and is uniformly loaded, the braces in the centre panel have no action.

Col. Merrill, in his recent work on Bridges, refers frequently to "the counterbalancing of equal weights similarly situated on symmetrical trusses," "each balanced weight goes undivided to the nearest abutment." But why do equal weights similarly situated counterbalance? Is it not because they produce equal horizontal action? Suppose they are not equal weights, is it not possible for them to produce equal horizontal action and counterbalance by not being similarly situated? Or, suppose the weight on one half to be concentrated at its centre of gravity, it will still counterbalance the weight on the other half, because it still produces the same horizontal action.

Let one-half of a bridge be uniformly loaded with a certain weight, and the other half be uniformly loaded with a greater weight, and let this be a permanent load; when the braces are arranged to bear this, none of them will cross each other, but from the point where the horizontal strain is greatest they will incline to either abutment, as in a uniform load they incline from the centre. If a bridge be uniformly loaded, as stated before, no counterbraces are necessary, and there is no shearing strain or vertical force at the centre. Add to this, at one end, a load, and the result is that the place of the greatest horizontal strain leaves the centre and approaches the load, its approach being guided entirely by the amount of the load. From this point of the greatest horizontal strain the braces must now incline both ways to the abutment. In other words, counterbraces are needed between the point mentioned and the centre only.

If this uniform load be taken as the weight of the bridge, we can easily see how it is affected by the advance of a train. Remembering that two braces cannot work counter to each other in the same panel, it is evident, if we have a weight at one end of a panel acting upon the main-brace, that it requires a greater weight at the other end to act upon the counterbrace; for an equal weight only neutralizes the vertical force of the first weight and produces only a horizontal action; therefore the second must exceed the first before it can affect the counterbrace.

Let us now apply this to one of the examples in Col. Merrill's work, say the Jones Truss, and use, for greater simplicity, only the vertical components of the strains. Unloaded, the weight of the

bridge produces a strain on the main-brace in the second panel, of 60,937.5 lbs. Bringing the head of the engine to the centre of the panel (advancing on the bridge) it is calculated that it imposes a strain of 1,100 lbs. on the counterbrace in this same panel; but this cannot be, for the two braces cannot act at the same time. In truth, it lessens the weight on the main-brace in this panel by 1,100 lbs., making it 59,837.5 lbs., increases the weight on the first main-brace, affects the other braces, and draws towards it the point of greatest horizontal strain. So far, counterbraces are therefore useless. The same case occurs in the third, fourth, fifth, and sixth panels, but in the seventh the weight from the engine and train that is carried towards the centre, is 21,636 lbs., while that from the bridge itself on the main-brace, is 14,062.5 lbs., and a counterbrace now becomes necessary, but it has only a weight of 7,573.5 to sustain. This can easily be proven graphically.

We need therefore in this truss only two counterbraces on either side the centre, and they bear 18,000 lbs. less than they are proportioned for, and there are about 7,500 lbs. of counterbrace entirely useless in one truss on the Jones plan, as given by Col. Merrill. The same misapprehension prevails in regard to the other plans, and has probably arisen from never taking into consideration the effect of the weight of the bridge itself when calculating the effects of a partial load.

TRACTION OF LOCOMOTIVES.*

From "The Railway Times."

Traction of locomotives is the work performed through the machinery, and developed at the rail. To many it is synonymous with power; which, strictly speaking, is wrong. Traction analyzed is but weight. Power is weight multiplied by time. There is not, and cannot be, practically, such a calculation as horse-power of a locomotive, from the fact that an engine may be running fast, and using little steam, by partially closing the throttle, and still show more power than when running slow and using heavy pressure to end of stroke. The reason is apparent. But the force it exerts, and the velocity it moves at, can be calculated.

To those who have seen a dynamometer at work, traction and its relations are a study. I do not propose to enter into a series of precedents on this subject, but merely give my impressions as they came under my observation. And when I say impressions, I do not mean facts or conclusions, but only that transition state between them and emotions —that broad, middle ground, where conjecture is developed by experiments as truth, or abandoned, from the same clause, as misdirected impulse.

On first view, one hesitates, from the extent of ground embraced, including the resistances of over-loaded cars, cars out of order, bad lubricants, friction, gravity, condition of engine, rails, track, curves; proportion of dead to paying load might possibly come under this head. The ground is so wide, opportunities so scarce, time so limited, and ability probably lacking, that a mere cursory view is all that one, leading the active life that we do, can give this subject.

On the roads of the South, where ballasting is limited, where the heavy rains of winter preclude, or nearly so, all work on it, and at the same time when the heaviest traffic is carried, is probably where resistances to traction are most varying.

An engine weighing 30 tons, giving a weight on each driver of 10,000 lbs., at a speed of 30 miles per hour or 44 ft. per second, strikes a low joint; the force or momentum to be absorbed by springs, etc., is enormous, as per example: Height due that velocity by formula is 44.8 $2 = 5.5$ $2 = 30.24$ ft. 10,000 $35.25 \times 64 =$ 440,000 lbs.; or force enough to move 2,750 cars of 16 tons each, were it possible to so apply it; which it is not. Some of this, a great deal too, is absorbed by the acuteness of the angle that a line drawn from point of contact to centre of wheel would make, which in a 6 feet wheel is 78 degs., and in a two feet wheel is 65 degs. The balance is taken up by

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* The above paper was presented by Mr. L. H. Sellers, of the Memphis and Charleston Road, before the American Railway Master Mechanics' Association.

the spring and reciprocations of equalizing beam. But for this no machinery could stand it. If the blow was received directly opposite the centre of the wheel horizontally, it would bend or break the frame or crowd the pedestals off.

The engine passes over the place with an interval between the striking of it by each driving wheel of $\frac{1}{8}$ of a second, a scarcely appreciable time, but long enough for dynamometer to show, by a jump of 1,000 lbs. or 1,500 lbs., that it also felt the blow, and long enough also for the engineer to feel each wheel as it strikes. This is but one of the incidentals of high speed on rough track. Another is the fact, that the trucks are alternately going up and down hill. The sinking of one tie but a single inch under a heavy loaded wheel makes a rise of 1 in 30 for that wheel the traction force necessary to overcome, which is 66 lbs. per ton. But it is said, there is the down grade equal to the rise; this is scarcely so, as the low place gives way under the wheel, and only reaches its lowest point where the weight of the wheel forces it there, leaving nothing but the spring of the rail to assist up the hill thus formed. And an inch is scarcely half of what ties sink during the long wet spells of the South. This adds to power required, and consequently to cost of said power. That axles do not break oftener under such treatment seems strange.

An engine 15 $\times$ 22, 5 ft. wheel, 120 lbs. pressure, should exert a tractive force of 9,000 lbs. at least. On a grade of 48 ft. per mile, with a load of 5 freight, 1 baggage, and 2 passenger cars, weighing with engine 350,000 lbs., it gave out on dynamometer 8,000 lbs. to start; after a revolution or two 9,000 lbs. until train was under headway; on pulling lever back 2 or 3 notches it required a constant strain of 6,000 lbs. to attain and maintain a speed of 25 miles per hour. On grades of equal heights and similar curves, with a start which is merely using the work stored up on the down hill, and can be calculated by multiplying weight by velocity, being what is called momentum or headway, the amount due gravity was 3,181 lbs., friction 2,134 lbs., leaving 2,685 lbs. to be absorbed or used up by suddenness of start; or rather it requires that to overcome the dead weight or inertia, and establish motion in a short distance. Engineers have all observed how long it takes to get up speed on a train when using a moderate throttle and cutting off pretty well back.

A calculation as to the assistance of momentum, compared with actual results, as above. It required 6,000 lbs. to maintain the same speed from a state of rest that 3,000 did with a start. 25 miles per hour is 37 ft. per second. Call the grades 2,600 ft. long, the statement is 350,000 lbs. weight of train by 24 lbs. height of

grade=................	8,400,000 lbs.
Friction at 18 lbs. per ton for engine and 10 lbs. for cars 2,134 $\times$ 2,600..	5,548,400 "
Making a total of......	13,948,400 lbs.
3,000 lbs. amount dynamometer showed by 2,600 =..............	7,800,000 "
Leaving, to be overcome by headway, a deficit of	6,148,400 lbs.

which, divided by total weight of train 350,000 lbs. is 17 ft. as the height due velocity, or the height that the weight would have to fall to make up deficit. Reduced by formula, square root of 17 $\times$ 8 = 328 ft. per second, giving an inherent velocity in train at foot of grade, of 22 miles per hour.

With a 14 $\times$ 24 $\times$ 60 in. wheel, 100 lbs. to 120 lbs. pressure giving a tractive force of 8,000 to 9,000 lbs. and a load of 250 tons, it required 6,000 lbs. to start on a level, 6,500 to 7,000 lbs. on a grade of 45 ft. per mile, or 1 in 117. The engine stalled, as it passed over centre; just before stalling, the hand fell as steam was released in cylinder to 4,000 lbs. At low speeds, from 5 miles upwards, this did not occur. On broken grades of equal height this train was readily kept at a speed of 18 to 20 miles per hour, with only 3,000 lbs. shown, or about half what it required to start the same on a level.

Having repeatedly tried light passenger trains, say 3 to 5 cars, I have found that while it required 3,000 lbs. to start them, the speed was easily kept to the maximum, 25 miles per hour, with from 1,500 lbs. to 2,000 lbs. on grades, and as low as 1,000 lbs, on level.

These results vary with different engines, as some roll away from train on down grades, while others set back against

it and require to be pushed. Observing as closely as I could, I have been able to get all the calculated power from engines that were in any kind of condition, after a little speed had had been attained, say 4 miles per hour. Few give it on a dead start; in fact, I have not seen any do so. This is to be attributed to the lead, or rather early exhaust, as I have not been in the practice of giving any lead or steam side at full stroke, judging that the increase on link was enough, even to overcome the loss of it by lost motion in valve gearing.

ON THE MANUFACTURE OF CRUCIBLE STEEL.

By R. H. SMITH, F.C.S., Etc.

From "The Artisan."

A great deal is being said about the production of cast-steel directly from iron ores, or its manufacture from inferior kinds of English iron; but little is known or said (outside the immediate manufacturing districts) as to how the immense quantities of this substance are produced at the present time. The conversion of iron into steel is, perhaps, to be classed among one of the most peculiar, but, at the same time, interesting processes with which chemists are acquainted.

The ordinary converting furnaces are of a conical shape, the bar-iron laying in stone pots, in contact with charcoal; and the heat to which the iron is exposed is regulated according to the purpose for which it may afterwards be required. The time generally occupied in what is termed "conversion" is about three weeks, a week being taken to raise the heat to a sufficient degree, a second to maintain it at the required temperature, and a third to gradually cool the furnace. When cold, the bars are withdrawn, and found to be covered with blisters, and, if broken, possessing a fracture totally different in appearance to that shown by the iron before treated in the manner described. Several tempers, as they are technically called, are produced in one furnace, and much care is necessary in selecting them out for the different requirements of the melter.

Too much care cannot be taken in the melting of steel, as the after-work so much depends upon this part of the process. The melting-holes are on a level with the floor of the furnace-room. Each hole has a flue; and some six, twelve, or more, of these form a flat stack. The grate bars at the bottom of each hole are approached by means of a cellar below. The crucibles, or pots, as they are called, made from a mixture of several kinds of clay and a little coke-dust, are formed into shape by means of a plug and flask. The pots are annealled over night, and when at a dull red heat in the morning placed in the holes by means of tongs, each furnace taking two pots.

The bar-steel of the required hardness is now broken up, and the crucible charged by means of an iron funnel. The first heat, as it is called, will take from four to five hours before it is ready to be poured; but this greatly depends on the nature and hardness of the steel. The holes are watched and worked by the puller-out; but the word to draw the pot is given by the melter.

The puller-out now lifts the crucible from the hole with large tongs, and places it upon the floor of the furnace. Its contents are then poured by the melter into a mould, made of cast-iron in two pieces, covered with a coat of coal-tar soot, and are held together by rings and wedges.

Great care is required in pouring or teeming the steel, as it is technically called, and skill in judging the proper heat when to cast it. Mild or soft steel should be teemed immediately the pot is withdrawn from the furnace; but hard steel may often remain a few minutes with advantage. Each crucible should last one day, and is used three times, with charges of fifty, forty-five, and forty pounds respectively.

All steel above a chisel temper contains 0.90 to 1.00 per cent. of carbon. If well melted it will settle down in the mould, leaving a small hole at the top of the ingot. If, however, the molten steel has not remained long enough in the fire, it will pour fiery; and if the ingot, on cooling, be broken, it will be found to be full

of small holes, called honey-combs. Great precaution must also be used in not allowing the metal to remain too long in the fire, as hard steel, when of good quality, will soon scorch, and so render the ingot very brittle.

Well melted steel (say of a cool temper) may be thus known The ingot will be of a blue color, with a smooth and even skin; the fracture of uniform brightness, and the outer edge perhaps slightly scorched.

Another very important operation to which steel is subject is the hammering; and probably more good steel is spoiled in this department than any other. The ingot should be well soaked in the flame of the forge furnace, and not at once (as is often the case) put into a dead fire—where the heat is what is called dead—and where no flames surround the ingot.

The fineness of the fracture of a bar of finished steel greatly depends upon the heat that the bar is allowed to retain when the finishing stroke of the hammer is upon it. Coarseness and fineness of grain, as judging the temper of quality of cast-steel, is far overestimated. It is, to a certain extent, an indication of hardness; but so much depends upon the way the bar has been finished, that it is of little practical value. However, best cast-steel, especially when hard, will show a fracture of a silky nature; and when soft, will look bright, and shine like glass.

Common cast-steel, on the other hand, will lack that brightness which is so characteristic of good steel; it will look dull, and have, so to speak, a leaden appearance about it.

In the working of steel too much care cannot be bestowed; and where, as in razor making, the workman is required to use a steel containing 1.50 per cent. of carbon, the durability of the razor will almost entirely depend upon the heat to which he subjects it while forging it into shape.

A useful tool-steel will contain about 1.2 to 1.35 per cent. of carbon. Spindle-steel, or large size turning tools, will work well if containing about 1.15 per cent. of carbon. Chisel-steel is a temper much used, will harden at a low heat, and possesses great toughness. Steel of 0.85 to 0.75 per cent. of carbon will weld easily, and is adapted for cold-sets, or tools where the principal punishment is on the unhardened part.

In melting, charcoal is largely used when the bar-steel is not of the required hardness. Wolfram and titanium are occasionally used, but with little advantage.

Binoxide of manganese is universally employed. It forms a good flux, and protects the molten steel from the action of the air.

Spiegeleisen is much used in Sheffield. It is an alloy of iron with manganese and carbon. The following is an analysis of a good spiegeleisen :

Iron (by difference)	84.78
Manganece	10.21
Carbon	5.01
	100.00

Among the many irons employed in steel-making, none have acquired the reputation that those imported from Sweden have won for themselves, and especially those known as the Dannemora marks.

Such brands as double Bullet (OO) and hoop L (L) command a high price, and are much used where the best quality of steel is required. Second Swedes, such as Wand Crown, Steinbuck, Great S, K6, etc., are good-bodied irons, largely employed, and making a very good steel. Of the commoner marks may be quoted (C$\overset{\text{m}}{\text{W}}$) SV8) Spider, and $\overline{\text{I-G}}$; and where a high price cannot be obtained for the steel, such brands are recommended, being found to melt and work well. English irons and spring ends are melted, but make an inferior quality of cast-steel.

The following is an analysis of tool-steel :

Iron (by difference)	88.34
Carbon	1.31
Manganese	0.12
Silicon	0.19
Sulphur	0.03
Phosphorus	0.01
	100.00

The earliest stained glass of which we read—the earliest in England, at least—was in the possession of Rivaulx, about 1140.

THE DARIEN CANAL.

From "The Scientific Journal."

The success of the Suez Canal will no doubt give impetus and encouragement to enterprises of the same kind.

Since the year 1860 a French civil engineer of talent has been engaged in the difficult and dangerous task of surveying the Isthmus of Panama, for the purpose of finding the best line for a ship canal across it.

We clip the following extracts of his final report in our files of the New York "Tribune:"

The proposed canal has its entrance on the Atlantic side at Puerto Escondido, where vessels can anchor in a depth of from 17 to 44 fathoms. Thence the proposed canal follows the valley of Turgandi, and passing behind a small hill called Tarers, continues on in the valley of the River Tanela, to the source of this river. The hollow in the chain of hills, at its highest point, is here only 46 meters above the level of the sea. The canal would here enter the valley of the Pucro (on the Pacific slope), and follow it until reaching the Tuyra, 4 miles above the point named Santa Maria Real, at which place it enters the river, and thus is brought 3 miles below the highest point reached by the tide in the river Tuyra. The canal will require 88 kilometres, or 22 leagues, of excavation. From the western entrance, at Santa Maria la Real, to the Gulf of San Miguel, by "Boca Chica," there will then remain 65 kilometres to be navigated, in a river which at present has a profundity of from 7 to 20 fathoms. The distance from ocean to ocean will thus be 153 kilometres, or 38¼ leagues. The height throughout the proposed line, taking the highest and lowest points, presents an average of 11 metres 90 centimetres. The canal would be 70 metres wide at top, and at the bottom would be 50 metres—thus allowing ample room for the passage of the largest steamer yet built. Considering the diverse formations presented by the different sections of the route, which comprise earth, clay, schist and earth, sand, lava, stones and rocks, the following figures present the maximum cost of the work, and which would be reduced materially by the employment of machinery to the excavations :—

87,800 metres at $600,000 the kilometre	$52,680,000
Allowance of 10 per cent. for any difficulties which may arise in the excavations	5,320,000
Machines, tools, &c	800,000
Clearing the line	1,000,000
Expenses of general management for 5 years	1,000,000
Agencies in Colombia	100,000
Engineers and superintendence of the work	600.000
Houses, sheds, hospitals	800,000
Sanitary service and medicine	100,000
Extra provisions	400,000
Lamps, levees and wharfs	200,000
Drags	200,000
Ports at each extremity of the canal	200,000
Telegraphs, double wire and exchanges	200,000
Railroads, &c	2,000,000
Provisions for directors, engineers, agents, instruments, &c	400,000
Mules	200,000
Ammunition, arms, mining powder	200,000
Steam and sailing vessels to bring provisions	400,000
Accidental expenses	3,000,000
Total	$70,000,000

The quantity of earth to be excavated in order to open the Colombian Canal is 125,000,000 cubic metres, which being divided into 20 working sections give 6,000,000 cubic metres to each section, so that if the work were to be commenced along the whole line, within a period of from 3 to 6 years the canal would be open for navigation.

The earth to be excavated may be divided into the following proportions: 1. Earth, sand, clay, etc., 45 per cent. 2. Small stones and stones removable by labor, 34 per cent. 3. Rocks of different formations which will require blasting, 21 per cent.

The highest point of the saddle in the chain of hills is 46 metres in height by 9,000 metres in length, and will require the removal of 31,000,000 cubic metres of earth, being equivalent to the fourth part of the whole work.

The whole of this data is obtained from documents now in possession of the Society, which are already approved of in Europe, and will be presented to the Congress about to assemble in Bogota. The maps of the Society have been approved by the Admiralty of England (and also by that of France) as the most complete.

GUN EXPERIMENTS.

From "The Artisan."

It is deeply to be lamented that a certain amount of antagonistic feeling appears to exist between those who regard the present Ordnance service-gun with favor, and those who put their faith in our esteemed member, Sir Joseph Whitworth, and the merits of his rifled ordnance. The Ordnance authorities, on the one hand, appear to hesitate adopting, or at least, trying what I am to understand the Admiralty authorities, on the other hand, have determined to give a fair trial to, namely, the 35-ton gun on the Whitworth rifled system with elongated shot. If this intention be realized, there will be an excellent opportunity of a fair trial on what I conceive to be correct principles, stated thus:

The value of a rifle-gun may be properly estimated by the lowness of its trajectory and the length of its shell. To obtain these two important elements in the greatest degree, it is requisite that the gun should consume a column of powder not less than three diameters in length, and without producing a permanent alteration in the diameter of its bore by the explosion. The power of hitting objects at unknown distances depends greatly on the lowness of the trajectory. At very short distances a shorter shell may give a somewhat lower trajectory than at longer ones.

But for destructive effect at very short distances, Sir Joseph Whitworth clearly showed in the paper he read on the penetration of armor plates, at the meeting of the British Association at Exeter, that shells twice the ordinary length gave the greatest penetration, while they contained double the ordinary bursting charge.

It is highly desirable that there should be some fixed standard of length of range at which all guns should be fired. If such standard of length were adopted, the merits of guns and ammunition would be at once known, by simply recording the elevation at which the standard distance was reached and the length of the shell, expressed in diameters of the bore. The longer the projectile, and the lower the elevation at which it is propelled, the greater is shown to be the power of the gun.

One thousand yards may be now considered a short range for artillery; and as upwards of 11,000 yards (more than six miles) has been attained, a standard range of from 2 to 3 miles would answer the purpose. If this were carried out, any one would be able to form a correct opinion of the value of any particular gun. For want of some standard, very confused notions now prevail on the subject of rifled guns.

It is very difficult to attempt to compare two guns having nothing in common. For instance, to compare the 7-inch service breech-loading gun and the 7-inch Whitworth:

	Elevation.	Shell. Diameters long.
7-inch service gun, range 3,660 yards	9° 54′	2
7-inch Whitworth, range 5,000 yards	10°	3½

Although it is obvious how much more powerful one gun is than another, it would have been far better for the ranges to have been the same, and the difference shown only in the elevations, and the length of the projectiles given in diameters of the bore. The length of the Whitworth shooting gallery at Manchester being 500 yards, it was the practice to compare the performances of different rifles and their ammunition at that distance, and 500 yards became the standard of length.

The following shows the qualities of the Enfield and Whitworth, as developed in April, 1857:

	Elevation.	Length of Bullet. Diameters.
500 yards range, Enfield rifle, large bore	1°	2
500 yards range, Whitworth rifle, small bore	1°	3

Other qualities, such as accuracy or figure of merit, charge of powder, weight of bullet, weight of rifle, etc., it may be desirable to know; but the key-notes are elevation and length of shell, which at once decide the value of the arm. In 1852, the average shooting of six rifles made by the best makers in London, was 33 in. deviation. The shooting of each rifle is recorded in a book printed by the War Department, which I have seen, and which affords evidence of the great advance made in the science of gunnery since that time.

The shooting of the Whitworth rifle is now, as it was at Hythe in April, 1857, 4½ in. at 500 yards, with 10 successive shots.

An infantry soldier will probably be as well armed with the new small-bore breech loader, as far as accuracy, rapidity, and distant firing are concerned, as he is ever likely to be. He is now able to fire 8 projectiles, 1 oz. each, per minute, and make good practice at one thousand yards. But the power of infantry for attack or defence, even with the new breech-loader, falls far short of what small bodies of infantry could do, if armed with 3-pounder field-guns drawn by 2 horses; each man would be able to fire a far greater average weight of ammunition, and of much more destructive character, than with the rifle. The trajectory at 1,000 yards for the 3-pounder gun, is not one-half that required for the rifle.

IRON AND STEEL NOTES.

THE IRON AND STEEL TRADE.—The Bulletin of the American Iron and Steel Association puts the product of pig iron in the United States, in the last five years, as follows: In 1865, 931,000 tons, net; 1863, 1,603,000 tons; 1869, 1,900,000 tons. During the last eighteen months, sixty-five new blast furnaces have been erected. Nineteen of these were in Pennsylvania. Thirty years ago the entire product of pig iron in the United States was but 50,000 tons, and the largest furnace was only capable of producing 1,500 tons annually. In regard to steel, the "Protectionist" has the following: "Within the last six years it has been demonstrated that the steel-producing qualities do exist in American iron, and many of our best edge tool manufacturers and machinists testify that steel, both cast and rolled, made in Pittsburg from American iron, is fully equal to the best English makes. The steel-producing capacity of the works in and around Pittsburg alone is estimated at 75 tons per day. This industry may, therefore, be deemed an accomplished fact, and, brief as its history is, it has already exercised an important influence in controlling foreign prices." It is shown that American axes, shovels, spades, hoes, etc., have entirely taken the place of foreign tools. Nothing equal to them in shape or finish is made abroad, and they are now largely exported. American butts and hinges of all kinds are cheaper and better, and entirely exclude all foreign goods. In cutlery of all kinds, the medium American qualities, of which the largest bulk enter into consumption, are cheaper and better than those of foreign importation; only the very low and worthless grades, or the very expensive and luxurious styles, can now be imported.—*Pittsburg Evening Chronicle.*

PUDDLING STEEL RAILS.—At a recent meeting of the Iron and Steel Institute (England), held at Middlesbro', some valuable and practical information was given on the subject of the manufacture of steel, and its adaptation to rails.

Mr. Edward Williams, the General Superintendent of Bolckow & Vaughn's Works, stated: "Strenuous efforts had been made by nearly all the great ironmakers to produce steel-topped rails, which, it was hoped, would be made much more lasting than the usual piled iron rails, and less costly than ingot rails. Puddled steel seemed to offer a cheap and good material for this, and after some difficulty to begin with, it was produced of very uniform quality. It was, no doubt, a material capable of resisting well the wear and tear of railway stock, but it could scarcely be welded at all, and as it could not be obtained in solid blooms for rail sizes, the system failed, and had been abandoned in this country (England) at least, entirely."

Thus we have the opinion of one of the most practical rail makers in England, that puddled steel is a "material capable of resisting well the wear and tear of railway stock," but that the attempt to use it failed simply because "*solid blooms for rail sizes*" could not be obtained (by the present system). Now what I wish to submit to the notice of the makers of rails of this country is simply that having been engaged at a rail mill, at which semi-steel rails were made in large quantities, and occasionally puddled steel produced, I devised a plan by which *solid blooms*, up to half a ton weight, could be made of steel or iron direct from the puddling furnace; such blooms, after being formed in a mould and submitted to hydraulic pressure, can, with one "wash-heat" be rolled direct into rails without being allowed to cool from the puddling furnace to the finished rail. I also found that by the most simple process, part of the bloom could in the mould be transformed into tough fibrous iron; by this means the web and foot of the rail could be made fibrous iron, and the head fine granular steel. This is no theoretical idea, as I carried my trial to perfection at a considerable expense and on a sufficiently large scale previous to my obtaining my Letters Patent for the method. There, then, is the plan complete for producing puddled-steel or granular iron-rails from one solid puddled bloom. This does away with piling blooms for rails, and gives a solid rail of far more reliable strength than ingot rails. Therefore, to make the rails superior and reliable, they must have a granular head and fibrous web and foot. But as the best iron-rail cannot bear the heavy rolling stock of the present day without too much wear, steel rails are now sought for. There is no reason why puddled steel may not be made in the same furnaces, and with the same men, as iron now is, and there is no necessity for new and expensive plant. By a few trials a good puddler can, with a proper quality of iron, make steel with as much ease as he can produce puddled bar-iron, and thus, by adopting the system alluded to, steel rails could be turned out instead of iron rails.—*Bulletin of the American Iron and Steel Association.*

STEEL MANUFACTURE.—The difficulty of melting steel in sufficiently large mass for some purposes is well known, as by the ordinary processes, owing to exposure to the gases of combustion and other causes, much deterioration of the quality is almost sure to be the result. As a partial remedy, the metal is usually melted in crucibles, but these are expensive and require constant renewal, and when a large casting is to be made it is necessary to use a large number of them, and it is

difficult to regulate their temperature so that all shall be at exactly the proper melting point at a given time.

A German founder recently announced a method used by him, by which the difficulties mentioned above may be obviated, and steel in any quantity melted and cast as readily as iron. He dispenses with crucibles, and melts his steel in a hearth of burned fire clay, capable of containing 1,800 lbs. The furnace is so arranged that at the proper time a bellows can be brought into play so as to bring the heat to the melting point in a very short time, and thus avoid any continued strain upon the hearth. To protect the melted steel against the injurious influences of the gases of combustion, it is covered with a coating, 1 or 2 in. thick, of melted green bottle glass, or furnace slag, made on a charcoal iron furnace, great care being taken to exclude any sulphur. About 70 lbs. of glass or slag will be needed for every 100 lbs. of steel. If one hearth will not hold enough steel, several may be used. The melted metal is to be drawn off in the usual way into kettles, lined with clay, and transported to the mould for casting.—*Iron Age.*

Blast Furnaces.—From a return recently published in "Ryland's Iron Trade Circular," of the blast furnaces in the various iron making districts of the United Kingdom, we abstract the following particulars.

Name of District.	Number of Blast Furnaces.		
	Number in Blast.	Number out of Blast.	Total.
South Staffordshire.....	102	72	174
North Staffordshire.....	27	10	37
Shropshire.............	21	8	29
West Coast.............	34	9	43
South Wales...........	111	87	198
Cleveland (about)......	101	14	115
Scotch.................	129	29	158
	525	229	754

Besides the furnaces above mentioned, there are in the Cleveland district eleven new furnaces now building, and in a more or less advanced state, while several of the Cleveland firms are rebuilding and raising old furnaces. Two new furnaces are in course of erection in the West Coast district.—*Engineering.*

Coal and Iron in the "Far West."—An interesting trial has just been made at the Union Pacific Foundry, Omaha, in the production of iron with coal from the territory of Wyoming. The result is said to have been very satisfactory, the iron being tough and strong, and with no trace of sulphur in its composition. It is thought that this may be the forerunner of many iron manufacturing establishments in Omaha, Nebraska and other portions of the Far West.

Prevention of Iron Rust.—Dr. Calvert has communicated to the Chemical Society some very useful information on the rusting of iron. Rust is mainly sesquioxide of iron, and it has always been supposed that the active agents in producing it are moisture and oxygen. It seems, however, from Dr. Calvert's experiments, that carbonic acid must be associated with these to produce any considerable amount of oxidation. In dry oxygen, iron does not rust at all; in moist oxygen, but little and seldom; but in a mixture of moist carbonic acid and oxygen, iron and steel rust very rapidly. In like manner, a piece of bright iron placed in water saturated with oxygen, rusts very little; but if carbonic acid is present as well, oxidation goes on so fast that a dark precipitate is produced in a very short time. Curiously enough, bright iron, placed in a solution of caustic or carbonated alkali, does not rust at all. These facts show that the points to be attended to in the preservation of iron from rust are the exclusion of carbonic acid and moisture, two indications which may be very easily fulfilled.

RAILWAY NOTES.

Rock Island Palace Car "California."—The dimensions and arrangement of this peerless car are the same as of the "Sacramento," 60 ft. long; lobby in each end, one containing a Baker Heater (enclosed in screen), toilet stand, water closet and wardrobe in the other, a baggage closet taking the place of the heater; state-room at each end of the grand saloon, accommodating 6 persons, with sofa, easy chairs, table, side light, mirrors, etc., 10 sections, in the body of the car, accommodating 40 persons, making the capacity of the car 52.

The chief novelty in exterior construction consists in the introduction of the Mansell wooden wheel, with steel tire—a wheel which, for elasticity, comparative freedom from noise, and durability, is likely to come into general use in the first-class passenger equipment of our best roads. The outer sides of the car are ornamented at each end with a bronze medallion, 2 ft. in diameter, of the California coat of arms—an exquisite piece of art; and the painting is of the same exquisite design and hues as that of its predecessors—the "tone" being harmonious with that of the interior decorations.

It is in these latter that we find originality and unexcelled beauty of design. The effect studied has been that of perfect harmony of tone between the wood-finish, the painting and the upholstering; and of an artistic *tout ensemble.* It is not merely that you have here in a space of 500 sq. ft. the varied and often meretricious ornamentation of an ambitious $25,000 city mansion. It is that the car presents, along with all the "modern improvements" of a first-class private house, the unity and harmony of effect of a master-piece of decorative architecture.

The ground-work of the wood-finish is mahogany; the panels are of purple-hued maple; the ornamental finish of the principal parts—arm chairs and sofas, around doors, mirrors, etc.—is of white holly, relieved with ebony piece-work, and set off with miniature medallions in gilt, a score or more gems of classic art. The ornamental work of the berths and raised roof is of original, unique, and beautiful design, which must be seen (as it is intended to be) to be appreciated. The centre-piece of the berth lining is a medallion—ground of black walnut, with bas-relief in white holly, of such *chef d'œuvres* of art as "Night and Morning," "Music," and other allegorical subjects. Starting from this centre, the lining is laid off in panels bound by various curves—these latter ebony, with gilt bands.

The head lining is in the same style—the patterns being varied. The colors of the ground are buff, in two or three shades, relieved with very delicate figures in gilt, red, and blue.

The upholstering is similar to that of the "Sacramento," the hues of the French moquette seats, of the Wilton carpets and of the berth and window tapestries, harmonizing with those of the walls and ceiling. At the upper corners of the doors are figures of Cupids exquisitely carved.—*The Iron Age.*

The Extent of Railway in Operation in the United States.—At the commencement of 1870 there was, according to the best information obtainable on the subject, 48,860 miles. This total does not include 3,500 miles of street railways existing in Boston, New York, Brooklyn, and Philadelphia. In the course of 1869 no less than 6,588 miles of new railway were opened in the United States—viz., in the North-Eastern States, 254 miles; in the middle Eastern States, 1,030 miles; in the South-Eastern States, 186 miles; in the Gulf and South-Western States, 223 miles; in the Northern interior States, 3,977 miles; and in the Pacific States, 922 miles. The aggregate expenditure upon United States railways in 1869 was no less than $358,707,678, of which $189,000,824, related to the Northern interior States. The aggregate amount of capital expended upon United States railways to the close of 1869 was $2,212,-412,719. The extent of railways in operation in the United States in 1830 was 41 miles; in 1835, 918 miles; in 1840, 2,197 miles; in 1845, 4,522 miles; in 1850, 7,475 miles; in 1855, 17,398 miles; in 1860, 28,771 miles; in 1865, 34,442 miles; and in 1870, 48,860 miles.

Depth of Rail Section.—The rail is practically nothing but a girder for supporting the weight of the train, and the stiffer it is at all points, the nearer it approximates in character to the bed of a planer, the better it will fulfil the conditions required of it. In using fish-plates the joint is always the weak spot, because there is not the requisite amount of metal to resist the vertical pressure. The common form of iron rail, with 3½ and 4 in. depth of section, has always been regarded as too shallow for proper fishing at the joints, and the best engineers have advocated a change. We are glad to learn that on the New York Central the managers have now adopted 4½ in. for steel rails and 5 in. for iron. These standard depths, with a proper arrangement of the fish-plates at the joints, and a proper arrangement of cross-ties, will be a great advance upon the common practice, giving increased steadiness to the movements of the train, and a consequent prolongation to the life of the rolling stock. We commend these standard depths of rail section to other managers as the proper ones for adoption, especially for all roads with any considerable amount of traffic.—*American Railway Times.*

Uniformity of Gauge.—With a view to the establishment of a uniform gauge for railways throughout the United States, the following plan is under consideration by railway men and various members of Congress. Five-sixths of the roads already have the same gauge—say 4 ft. 8½ in. To bring the other sixth to this, as the easiest and cheapest plan, it is proposed that, after a given day, no road shall be a post road that does not conform to this gauge. The expense of changing a five-feet gauge to conform to this plan will not exceed $500 per mile, and it is believed that most of the roads could make the change at a less expense. As there are less than 8,000 miles of road requiring alteration, the whole cost of the work would not exceed $4,000,000. This sum would perhaps be saved to the country, by the change, in one year. As the United States are interested in having the most expeditious transportation of the mails and military stores, the public benefits to be secured, might, perhaps, justify an appropriation by Congress to make the change.—*Phil. Public Ledger.*

Pennsylvania Railroad Passenger Traffic for 1869.—We present an exhibit of operations in the passenger department more in detail than they were given in the reports hitherto published by the newspaper press:

Passenger Traffic of the Pennsylvania Central Railroad Company, 1869.

	No. Pass.	Miles.	Receipts.
First class....	4,200,607	134,930,814	$3,500,071 03
Emigrants....	28,756	9,797,838	131,065 93
Total........	4,229,363	144,728,652	$3,631,136 99
Regular Express....................			181,995 00
Extra Express......................			120,659 54
U. S. Mail.........................			118,961 21
Total earnings from passenger trains			$4,052,753 44

The gross revenue derived from first-class passengers and emigrants in 1868 was $3,610,148.23, and in 1869 $3,631,136.99, showing an increase of $20,988.76.

In the year 1868, however, there was included the sum of $107,777.63—money received for the transportation of Government troops in previous years. This sum, in making a comparison of the two years, should be deducted from the receipts for 1868. The result would show an actual increase in the first-class passenger business for the year 1869 of $128,766.39.

Of this increase there was from—

First-class passengers................	$75,944 75
Emigrants..........................	52,821 74
Total..............................	$128,766 36

The number of through passengers between Philadelphia and Pittsburg in 1868 was:

1868	96,228
1869	124,830
Increase...........................	28,602

The number of local passengers in 1868 was:

1868..............................	3,650,950
1869..............................	4,104,533
Increase..........................	453,583

Included in this statement of the local passengers given, are all passengers coming to or leaving the road at points between Philadelphia and Pittsburg; also the passengers to and from New York, *via* Allentown, and those to and from Baltimore and Washington.

The total increase in the number of passengers carried is 482,185, and in miles 11,530,350—equal to an average distance of 34.22 miles, and equivalent to 407,686 through passengers, an increase of 32,479 over the previous year.

Of the 4,200,607 first-class passengers carried, 1,059,131 were of the "monthly coupon" and "school class," and of these and other local passengers carried, 1,860,199 travelled a distance of 7 miles.—*Chicago Railway Review.*

THE EUROPEAN RAILROAD SYSTEM.—A German paper has made the following calculation: A train composed of all the locomotives and railway carriages in Europe would reach from St. Petersburg to Paris, and would contain 400,000 passenger carriages and 500,000 luggage vans. The railways of Europe are carried over 62,000 large and small bridges, and go through 34 miles of tunnel. 150,000,000 cwt. of iron has been used for the rails, and 80,000,000 cwt. of coal is required yearly to feed the engines. The network of European railways includes all States except Greece, Lippe-Detmold, Waldeck, and a few other very small German States. It represents a length of 70,718 miles; 18,000 locomotives are employed on it; the distance these rush over during the year is 60,000,000 miles. If to this is added the distance passed over by passenger carriages and luggage vans, we get to 100,000,000 of miles.

SOUTH PACIFIC.—This road has been christened a variety of names. When controlled by the Pacific Road of Missouri (who built it as far as Rolla), it was the "Southwest Branch Pacific Railroad." When after its reversion to the State, Gen. Fremont got possession, it was called the "Southwest Pacific Railroad." Subsequently, on the failure of Fremont to carry out the terms of the charter, the road passed into its present hands (heavy Boston capitalists, who are eminently responsible men), it assumed its present title.

The progress of this road has been very satisfactory under the present *regime.* Sometime in November last we announced its completion and opening from St. Louis to Lebanon, 185 miles. Since then 15 miles more have been laid, and the Company confidently expect to get through track-laying to Springfield (241 miles from St. Louis) by the 20th of April next, and reach Neosho, 50 miles further, by the 1st of July. One regular daily passenger and two freight trains now run to Lebanon, there connecting by stage to all southwestern points. The traffic is good, and returns for the past fiscal year indicate a profit of 50 per cent. Though the actual terminus of this road is Springfield, it is destined to be an integral portion of the great through line of the Atlantic and Pacific, *via* San Diego and Albuquerque to San Francisco. New lines also are contemplated and being built, which will intersect this line and add to its revenue.—*Chicago Railway Review.*

THE CENTRAL PACIFIC RAILROAD.—The courtesy of the officers of the Central Pacific—the California side of the railroad connection to Promontory in Utah—gave me, last evening, the pleasure of a ride on the engine *up* the Sierra and round Cape Horn, and to-day an opportunity, from the same point of observation, of enjoying the ride through the rock walls of Humboldt and Twelve Mile Canyon.

My thanks are due to Mr. Crocker and Superintendent Towne for the bit of pencilled paper by which I was enabled to enjoy one of the most delightful experiences of my life.

The real difficulty in the way of engineering, in connecting the two oceans, occurs on the western side. It is all plain sailing on the eastern till the road descends by a steep grade and through a pair of long tunnels into the Salt Lake Basin by Weber and Echo Canyons. The level plains of Nebraska, and the high table land of the Laramie Plains, by which the road ascends and crosses the Rocky Mountains, at an altitude of 8,000 ft., offered no difficulty to the engineer. The trouble on the Union Pacific was from the Indians—the warlike Sioux and Cheyennes—and from the fact of the great distance from supplies and material.

But on the western side, the engineering problem was the great one from the start.

Immediately after leaving Sacramento the ascent begins, and the problem was to ascend the Sierra Nevada range to a height of 7,000 ft. within a distance of 80 miles.

There was no getting round the thing. The mountains stood there barring the way eastward. They would not get out of the way for a railroad, and the "passes," by which travellers in the old time surmounted the obstacle, are all from 5,000 to 8,000 ft. at their height above the sea level.

It was, indeed, the common talk in California that it was impossible to carry a railroad up the western face of the Sierra. Even good engineers considered the undertaking preposterous.

It is easy enough to mount it from the east, for the high table land of the "great desert" comes up to its eastern side from 4,000 to 5,000 ft. In fact the Sierra Nevada is the western face of an embankment—the embankment being half a continent—and this, the guttered and storm-washed front of it towards the Pacific.

The point was to get up this rocky face to the table land it bounded, and to do that in a very short space, for the continent breaks off short and comes down sheer.

But California energy, using 10,000 patient Chinamen, solved the problem, and took the track up and over, along the mountain side, through deep and long tunnels, across rifted chasms in the rocks, over headlong torrents and by the dizzy edges of abysses thousands of feet down, and "around Cape Horn."

But even when the work was done, the snow avalanche or the earth slide from the mountain round whose side, half up, the iron path winds twisting upward, might sweep the work away, or overwhelm the track and make it useless for weeks or months.

There was a remedy also for this in the skill and determination of the men who did this work. They just roofed in their road for fifty miles!

They took the giant stems of the pines and braced them against the mountain side, framing them and interlacing them beam with beam. They sloped the roof sustained by massive timbers, and stayed by braces layed into the rock, and covered with heavy plank, up against the precipice, so that descending earth or snow would be shot clean over the safely housed track into the pine tops below, and so they run their trains in security under cover, and have conquered the snow in its own domain.

There is one drawback. These "snow-sheds" shut out forty odd miles of the most magnificent scenery on the whole trip—notably Donner Lake, and the deep valley enclosing it, which lies straight down below the passing trains.

It was up this slope I travelled yesterday afternoon and evening. It takes two locomotives to persuade the trains to ascend. I found a place

just after leaving Sacramento, on the foremost, and had a mountain ride, which I think must be unequalled considering the mountains and the horse.

First there was the Sacramento valley—oak opening all, which, to most of your readers, needs no description. Only the oaks are of a species not seen in Michigan or Wisconsin. California is rich in oaks, and these, scattered about as thickly as apple trees in an old orchard, are the live oak, small-leaved evergreen.

Then came the "foot hills" and a gradual change in the wood-growth. The Manzanilla wood, with its shining stem and dark-green glistening leaf, mingled with the oaks, and the buckeye, which, in California, is a many-stemmed bush, springing from a common root, hung heavy with its pear-shaped fruit, filling up the space beneath the taller oaks and the nut pines.

Finally, we came into the realm of the *coniferæ*, and the tall stems sprang up smooth, branchless, and tapering, rearing their green coronals to the sky.

We were going up the mountains! In a valley on one hand lay a mining village—the most beautiful villages in the State are these mining villages now. Down the mountain side, on the other, ran the water, led in sluices like a mill race, around a point here and a bend there, and across a gorge yonder—the water to be used under the mighty power its descent gives it to tear the hill side down and wash the rocks to pieces in "hydraulic mining,"—mining that is which consists in discharging a stream of water, with a head of a few hundred feet, full in the face of a hill side till it is knocked into bits!—bits which contain gold, of course, or are supposed to.

But these too are left, as we go clanking on through pitch dark tunnels and over trestle works that look like spiders' webs, and along the maze of dingy precipices, the engine coughing and straining in the tug up the steepest grade yet ventured by any engineer.

The day died out before we reached the summit, but died into a cloudless moonlight so brilliant, so silvery white in the flood of light it poured across land and sky, that one sent no regrets after the sunset.

Moonlight in the mountains, and such a moonlight is something to be remembered for life. I lost all sense of the poor every-day world, forgot so vulgar a thing as a railway car, even the clank of the engine seemed to come softened as from far away, and I was sailing over pine-clad mountains, silvery white, in an air of balm and fragrance, and, in fact, I think was about half asleep when my friend, the engineer, plucked my sleeve—we were doubling Cape Horn!

Round the jutting mountain wall, so called from its bold advance into the valley, and its precipitous face, the road winds like a ribbon. No human foot had ever trodden this height, as far as man may judge, till the first "hand" was lowered down to lash himself to a tree and begin, with pick and spade and crow, to cut a shelf along the dizzy height! Not even an Indian trail had ever passed where the long train was passing now. The footsure savage had never ventured here. Three thousand feet sheer down lay the valley, in the moonlight, like a lake, the mist slowly rising and swaying, silvered by the descending light. The feathery tops of the rock-anchored pines rose out of the mist far below. Across the valley the other mountain face frowned darkly, shaggy with bristling pines from base to summit.

That was one side.

On the other rose the almost perpendicular wall of the mountain, round which we were rushing on a shelf cut into the rock wide enough for the rails, of course—what need of anything more, when they are treble-spiked, and the rolling stock of the best, and the engineer the safest man to be found?

If we went off? If a broken rail should be ahead, if a rock should have rolled down beyond the curve yonder? Well, I suspect it would not make much difference, in that case, whether one was on the engine or in a car yonder. It would amount to the same thing, I think, when we all reached the valley together.

But there has never been an accident, and it is just such places as this that are most carefully guarded, and where all prudence, and forethought, and skill are engaged to be active.

I do not know that I have been able to give you half an idea of the magnitude of this undertaking, which has annihilated these weary desert spaces and brought East and West together. If I have said much about it, it is because, after all, looking at it as I have, it seems to me the railroad across the continent, the double iron bands that tie Omaha and Sacramento each together, over the mounains, across vast deserts where human life finds nothing to sustain it, through the territories of tribes, too, a few years ago a terror to the whole border—it seems to me the railroad is really the most wonderful thing one sees, after all.—*American Churchman.*

A Double bogie eight-wheeled 24 ton Fairlie engine, built for the Nasjo and Oscarsham Railway in Sweden, was tried on the 17th ult. on the Ring Railway of the Fairlie Engine and Steam Carriage Company at Hatcham, England. The engine was run round the curves of 50 ft. radius, at the speed of 20 miles an hour.

The New Chilian Line.—This land line is to start from Valparaiso, passing throug the capital, Santiago, Santa Rosa, and San Felipe, crossing the Andes at the mining town of San Juan; thence to Villa Maria, where it will join the line already established from Rosario to Cordoba, passing through Mendoza San Luis, and thence to Buenos Ayres, thus connecting the Atlantic and Pacific coasts of South America *via* the Cordillera. The contractors have been granted a subsidy of $3,000 by the Argentine Government, and it is to be completed within twenty months after the signing of the contract.

A Road Locomotive, Thompson system, has been recently experimented upon in Paris. of which the wheels were lined on their periphery with thick india-rubber bands designed to increase adhesion to the road. This answers well enough the intended purpose; but the question is, how long those bands will last, as they are very expensive, some $700 per machine.

ORDNANCE AND NAVAL NOTES.

The Moncrieff Gun Carriage.—An official trial of the wrought-iron carriage and platform, the first manufactured in the Royal Carriage Department, Royal Arsenal, Woolwich, for 12-ton rifle

muzzle-loading guns, from designs furnished by Captain Moncrieff, Edinburgh Militia Artillery, was made last Friday at the proof butts, Royal Arsenal, Woolwich, in the presence of a brilliant party of officers. The weight and dimensions of the carriage and platform were: Weight of gun, 12 tons 11 cwt. 2 qrs.; carriage, 2 tons 5 cwt. 2 qrs.; elevator, 7 tons 14 cwt. 1 qr.; ballasting elevator, 15 tons 1 cwt. 3 qrs.; platform, 9 tons 6 cwt. The total weight was thus 46 tons 14 cwt. The length of platform is 19 ft., and width 11 ft. The height of axis of gun in loading position, 7 ft., and in firing position, 13 ft. 3 in. The ammunition used upon this occasion was the test iron cylinder for a 9 in. Woolwich muzzle-loading gun, weighing 250 lbs., the powder was rifle large-grain. The platform on which the gun and carriage were mounted stood upon a horizontal platform of wood, two 1 in. iron plates being placed under each of the trucks of the Moncrieff platform. A balk of wood, to serve as a central pivot for the platform, was placed on an incline, one end against the middle transom, and the other end pinned down to the ground platform. The object of the balk was to prevent the movable platform from being carried to the rear on firing. Round 1.—Powder charge, 30 lbs.; projectile, 250 lbs.; recoil almost full. After firing this round two additional balks were placed, as the one before described, to prevent the anticipated backward movement of the platform. Round 2.—Charge, 40 lbs.; similar projectile as last; recoil all but full. In running the gun up after loading the third time the pawl of the rack on the right side of the carriage, from the want of attention or inexperience of the man who had charge of it, was allowed to fall into the rack when the gun was half way up, thus preventing the gun from going any further. The gun was worked back and the pawl removed from the rack. The pawl pin having been slightly bent, the pawl was altogether removed. Round 3 and last.—Powder charge, 43 lbs. (battering); recoil full and perfect. The recoil of the gun at this round acting on the timber balks doing duty as a pivot, caused a rebound forward of about half an inch of the Moncrieff platform, and all the weight upon it. The gun was under complete control throughout the experiment; the recoils were not at all violent. All parts acted with perfect success. We understand that the carriage and platform will now be forwarded to Shoeburyness, to be placed in the hands of the troops at the School of Gunnery for a more extended trial. The result of the experiment is considered highly satisfactory.—*London Times.*

The "Stuart" Breech-loading Cannon.—Although experience thus far has demonstrated the extreme unreliability of breech-loading artillery in active warlike operations, their invention and trial is still a matter of much interest and attention to projectors of new forms of military implements and enginery. The following is a description of a new English breech-loading cannon, which was lately brought before the "United Service Institution" (London) in a paper read by the inventor, Captain Graham Stuart. One of the guns has withstood the firing of 100 rounds, and it is understood that a 300-pounder on the same plan will soon be constructed at Woolwich Arsenal:

"An ordinary gun forging, somewhat enlarged in the internal diameter of the breech, is bored as usual, but the part of the boring in the breech is made 2 or 3 times as large as the remainder. Into this a sphere of metal, perforated as the bore, is introduced. One face of this has a *spiral* perpendicular projection. This fits against a bronze expansion ring fitted into the rear end of the bore, and acts as a wedge, completely sealing the breech. This sphere is mounted on gudgeons, which pass through the sides of the breech, and is turned by handles outside the gun. It rotates on its axis a quarter of a circle to open or close the breech. The perforation being accordingly in a line with, or at right angles to, the bore, the sphere rests against a heavy perforated breech plug screwed into the solid breech. Through this the charge is introduced; the operation of opening and closing is easy and expeditious; so much so that, whereas an Armstrong gun requires 10 men to work it, this gun can be worked with 8. The openings in the breech being the smallest possible consistent with breech-loading, strength is secured. The simplicity is evident from the fact that there are only 3 principal parts of the breech concerned in resisting explosion and force, namely: the plug, ball, and expansion ring. The prevention of gas escape is completely obtained. In the course of repeated trials this has been carefully tested; but none has been observed. Other advantages are the absence of openings into the sides and top of the breech, and the rapidity of fire attainable. The inventor has fired 6 rounds in 35 seconds, equal to 10 rounds per minute. The gun will stand hard work and rough usage. It was left without cleaning for several days, and at the end of the time the breech was opened without difficulty."

American Small Arms.—Breech-loading rifles are about to be substituted in the United States Navy for the muzzle-loading rifles still in use in that branch of the service, the ships' companies and marines being supplied with similar weapons. On the 29th of March last, the naval bureau at Washington instructed a commission appointed for the purpose to make an examination of the best system in use, and to test them thoroughly for endurance, convenience, and efficiency.

In accordance with these instructions, the committee invited the submission of different designs of breech-loaders that should conform with the specified regulations. Fifteen different arms were forwarded for the inspection of the committee. These were divided into six classes: the lever system, with perpendicular sliding breech block, the bolt and horizontal sliding block, the bolt and hinged block, the combination of bolt, ratchet and lever, the swinging or hinged block, and the Remington system, wherein the breech block is pivoted below the level of the chamber, and which does away with lever and bolt. It is this latter system which the committee, after exhaustive trials, though by no means so thorough and exhaustive as were conducted by our own small arms committee, ultimately decided upon adopting. To the breech mechanism has been added the Springfield barrel calibre .50. With regard to the cartridge, that in extensive use in the United States Army has also been recommended for the Navy. The powder charge is 70 grains, the weight of bullet 458 grains, and the cartridge is enclosed in a copper case, provided with central fire, tallow, and beeswax lubricant, and a cardboard wad between bullet and powder. The best form of cartridge was, however, found in the course of rapid and long sustained fire, to produce more or

less leading on the barrels, unless paper patches were wrapped around the bullet, and the final determination as to this detail of the cartridge has been postponed until experience has been gained as to whether such patches would deteriorate in quality during a voyage.

It is time that the United States should take action in the matter of an improved small arms equipment, but it is a pity that the labors of the committee appointed were so brief, for otherwise they would probably have secured a better arm for their service, just as with us a long period was requisite to bring the Martini-Henry to perfection. —*Engineering*.

New Gunpowder.—A new kind of gunpowder has been prepared by M. Brugére, by mixing 54 parts of picrate of ammonia with 46 parts of nitrate of potassa. The mixture produces, on burning, 10 atoms of carbonic acid, 6 of nitrogen, 6 of hydrogen, and as a solid residue, 2 of carbonate of potassa. The following are the advantages over ordinary powder, as claimed by the inventor: It is more homogeneous, and its effects are consequently more regular; it is far less hygroscopic; it is more effective for equal weights; and it leaves far less solid matter on combustion. The residue left after combustion does not affect metals, since it is only carbonate of potassa. This powder hardly emits any smoke at all, and what little is emitted is devoid of smell. The author recommends a mixture of 25 grammes of picrate of ammonia, 67 grammes of nitrate of baryta, and 8 grammes of sulphur as an excellent substitute for Bengal light, and as suitable for signal and port lights and use in theatres, since hardly any smoke is emitted and no unpleasant smell given off, while the light is very brilliant, slow burning, and yields a beautiful greenish tinge.

ENGINEERING STRUCTURES.

East River Bridge.—The caisson for the Brooklyn pier of the East River Bridge was successfully launched on the morning of the 18th of March. A large number of engineers were in attendance.

The last Proposal for Uniting England and France.—A French Engineer, M. Eugene Burel, has been in England to explain his plan for shortening the distance between England and France. He has nothing to do with bridges over the sea, or tunnels under it, but would simply improve it off the face of the earth; in other words, fill up the channel on both sides, and reclaim the land, leaving only a passage a mile wide to be traversed by ferry-boats every five minutes. M. Burel is a grave, serious gentleman, and really believes in his scheme, whatever our readers may think of it. They may like to hear him speak for himself, and this is what he said on the subject the other night at the dinner of the Society of Engineers, when he returned thanks as a visitor. "My scheme," said he, "is for neither a tunnel nor a bridge; it is the old mother land restored from the sea as it was seven thousand seven hundred and twenty-four years ago. Allow me to add one new county to England and one department to France across the channel, and thereupon to establish a railroad. By the time this will have been accomplished, with the increase of speed that will be attained I will make you go from London to Paris in five hours. I do not wonder that you laugh at the first communication of such an idea; for some of our master engineers said to me, in the similar instance, that this was a folly a little worse than the other proposition to the same end.

"However, I want you to think of it, and not to be too hasty in decreting the impossibility. One thing is in my favor, and that is the numerous examples of such restorations of land, although on a minor scale; and it requires nothing but a combination of the most approved systems of *assisting nature* (as your celebrated engineer, Telford, said), to accomplish this, at first, extraordinary looking work. Some say that England would never admit of being altered from its present situation of an insular land, to which she considers she owes her independence and her supremacy on the seas. I will not discuss now any political question, although I consider the unlimited increase of the means of communication between all the nations of the world to do the best some day or other, and set at rest every bit of unworthy consideration of this kind, especially when time will have still more proved the benefit of the general union of the trades and commerce between all nations.

"But I will say one thing, and that is, that assuming the isthmus to be still there as it was formerly, before the Diluvium Cimbricum, as reported from ancient traditions by Florus, and demonstrated by all the geological transactions, we should have to call M. de Lesseps to bore it, as there should be still a greater need of his scheme there than at Suez. Now, under such considerations, I would restore the land, not completely, but only so far as to leave a narrow channel one mile wide in the middle, and thus both the free circulation of the seas and the political question would be safe. In fact, my solution of the difficulty is a solution of contiguity. You say one mile is too little; I answer—No, it is not; for, I do not care whether it be one or twenty miles, when I think of the ferry-boats that are spoken of for the next year, which will be able to transport an army, or when I think of the guns that will soon afford us the possibility of firing against each other without parting from our shores. Had we not better advance at once, facing kindly to each other, so near as to shake hands over the water, while the ferry-boats would cross it every five minutes, transporting backward and forward all the treasures of our industries?"

With the best possible feeling, we advise M. Burel to waste no money on the prosecution of his scheme. We will not venture to say what changes in opinion may take place one of these days, but at the present moment England has no desire to give up her insular position.—*The Builder*.

French Public Works.—During the last seventeen years, under the regime of the late Prefect of the Seine, the city of Paris has expended on extraordinary works alone no less than 2,117,500,000 of francs, or £84,700,000 sterling, of which amount upwards of half, or £43,800,000, has been raised by loan, the remainder having been defrayed out of the ordinary municipal revenues. The interest on the sum borrowed is upwards of 46,000,000 francs, besides which another 10,500,000 is applied towards a sinking fund, and a further 10,000,000 by way of annuities. It results from this, remarks M. Lannau-Roland, who has furnished the forego-

ing figures to the "Patrie," that the rebuilding of Paris by Baron Haussmann, so far as it has gone, has imposed upon the city an annual burthen of 67,000,000 francs, to be reduced to 57,000,000 when the annuities have all fallen in; but, on the other hand, the annual revenue during the progress of these works has gradually risen until it has attained the high figure of 171.000 francs, which is not only sufficient to provide for all these charges, but leaves 37,000,000 francs (about 1,500,000 sterling) at the disposal of the municipality for new undertakings.—*Engineering.*

The Mont Cenis Tunnel.—During the past year an advancement of 1,431 45 metres has been made at the Mont Cenis Tunnel: of this, 827.70 metres were driven on the Italian side, at Barronneche, and 603 75 metres on the French at Modane.

The following shows the monthly progress made during 1869:

	Progress made at		Total Advancement made during Month.
	Bardonneche.	Modane.	
	metres	metres.	metres.
January	50.90	56 45	107.35
February	60.60	81.75	112 35
March	81 90	54.05	135 95
April	76.75	48 25	125 00
May	71.90	53.70	125.60
June	70 55	45.30	115.85
July	69.10	50.90	120.00
August	68.40	58 25	126.55
September	72.80	58.15	130 95
October	76 40	47 50	123.90
November	66.10	41.95	108.05
December	62.30	37 50	99 80
Lengths driven during 1869	827.70	603 75	1,431.45
Lengths driven previous to 1869	5,868.10	3,803 70	9,166 80
Total lengths driven	6,190.80	4,407.45	10,598.25
Remaining to be driven.	....	....	1,621.75
Total length of tunnel	....	....	12,220.00

The total length of tunnel *completely finished* on 31st December, 1869, was as follows:

	metres.
South side (Bardonneche)	5555.20
North side (Modane)	3669 75
Total	9,224.95

The average monthly progress during the past year was 119.28 metres, or 68.97 metres on the Italian side, and 50.31 on the French side; and at this rate of progress, the time necessary to complete the tunnel would be less than thirteen months, or about the end of January, 1871, and for opening the railway about six months later. or in about a year and a half from the present time. —*Engineering.*

Sinking Screw Piles.—A machine has been lately designed by an English firm at the request of H. Lee Smith, Esq., chief engineer for the Punjaub Northern Railway, for screwing down piles to be used in constructing bridges and flood openings on that line of railway. This machine consists of a wrought iron under carriage mounted upon wheels of 5 ft. 6 in. gauge, and carrying a vertical power at one end. A strong cast iron beam in the centre carries a cylinder in which works a ram, to the top of which a strong cross-beam is bolted which carries the machinery for operating on the piles. This consists of a horizontal steam-engine bolted to the side of the cross-beam, and driving a pinion and train of spur and bevel wheels which impart motion to two large horizontal wheels carried in bearings at each end of the cross-beams. A friction clutch is carried in the centre of each of the wheels, through the boss of which the shaft of the pile to be screwed is passed. The shafts are rolled with feathers or ribs on each side, which, passing through corresponding recesses or keyways formed in the boss of the friction clutch, form the means of imparting motion from the horizontal wheels to the piles; steam is brought from the boiler, through the centre of the ram and cylinder which carries the cross-beam, by means of a telescope joint, which allows the ram to be raised without interfering with the steam pipe; and a small donkey engine is provided which can pump from a tank situated between the frame, either into the boiler or into the cylinder under the ram which carries the cross-beam. When the machine is at work the cross-beam is held firmly by means of cotter bolts to the frame. The modus operandi is as follows: A temporary road being laid on the centre line of the proposed structure, piles are pitched by passing the shafts through the wheels on each side of the machine, and keying them into screws which are placed in a small hole excavated to receive them. The engine is then set to work, and the piles screwed down as far as possible. The cotters holding the cross-beam are then removed, and it is raised by the donkey engine pumping into the cylinder of the machine, and lifted off the piles. The machine is then moved forward to the centre line of the next pile, and the operation takes place as before.—*American Railway Times.*

Tehuantepec Canal.—The Minister of the Department of Public Improvement, Colonization, Industry and Commerce of Mexico, has transmitted to the Congress of that Republic a letter. containing the draft of a law authorizing the Tehuantepec Railroad Company to build a ship canal in addition to its railway across the isthmus. Surveys are to be made in 5 years and the plans must be approved by the Government. The construction of the canal is to be commenced within 3 years after the approval of the plans. The right of way and large grants of land are made in aid of the enterprise; the machinery, tools, coal and articles of prime necessity for the use of the employees are to be imported free of duty; the capital invested in the canal is to be free from contribution and taxation and no transit tax is to be levied. Various other important privileges are granted, but certain clauses would seem to place the stockholders at the mercy of the Mexican Government. The objectionable sections of the proposed law provide that "all persons now or hereafter engaged in the enterprise are to be regarded as naturalized Mexicans, and cannot bring forward claims as foreigners," and also that "controversies concerning the construction of the grant and the execu-

tion of the law shall be decided by Mexican tribunals." The Minister of Public Improvement recommends the granting of the application by the Tehuantepec railway, and asserts that explorations already made demonstrate that the Isthmus of Tehuantepec presents less difficulties than the Isthmus of Darien, to which the attention of the United States is now directed.

THE AUSTRIANS AND THE SUEZ CANAL.—The "Pall Mall Gazette" says: "Though the Austrians were confident in their assumption that the opening of the Suez Canal must redound to their commercial advantage in a degree which admitted of no rivalry by any other nation, the first instance of their profiting by this new route to India, is scarcely a fulfilment of their sanguine prediction. The screw steamer Apis, belonging to the Austrian Lloyds Company, of 1,200 tons burthen—a first-rate vessel, whose departure for Bombay was largely and widely advertised—sailed with a cargo of 130 tons! As the tariff fixed by the company is £3 10s. per ton, while the vessel pays a toll of 12,000 francs (£480) to the canal, and consumes 400 tons of coal on its voyage of 21 days, this beginning is surely not encouraging. Nor is the fact the more cheery that nearly one-half this small cargo was contributed by Venice. The company are evidently not deterred by this one experience, for they have now advertised the Sphynx, to sail 4 weeks hence."

THE HOLYOKE DAM.—The work of rebuilding this immense structure across the Connecticut river has been resumed. The dam is 30 ft. high and 1,018 ft. in length between the abutments. The fall of the river in the distance of ¾ of a mile is 60 ft., and the nature of the ground and the copious supply permits the water introduced into the canal to be used more than once. The preparations for carrying on the work have been very extensive. Two large flatboats and a new steamboat, 53 ft. long and 13 ft. beam, with engines of 20-horse power, are in progress of construction, to be used on the pond for the purpose of moving stone and materials necessary for the dam construction. A large boom is building, to hold 500,000 ft. of logs, to be sent down the Connecticut river. As soon as the water falls sufficiently, from 200 to 300 men will be put on the work.

THE FALLS OF ST. ANTHONY.—We read in the Philadelphia "Ledger:" "The mill seats on the Mississippi river, at Minneapolis and at St. Anthony, are arranged according to a novel device in hydraulic engineering. The bluffs of the Missisippi are composed of a stratum 14 ft. thick of limestone, supported by a layer of soft, white friable sand-stone. As the result of this formation, the Falls of St. Anthony have changed greatly within the last sixteen years. In 1854, the natural dam at this point was formed by a rocky ridge 16 to 18 ft. high, and the stream below was filled with immense blocks of limestone, which had fallen down from the ridge and the bluffs by reason of the washing out of the sandstone. This work of undercutting the limestone rock has been going on continuously, and the dam has been retreating up the stream. In order to prevent the further destruction of the Falls, the people of the town of Minneapolis, on the west bank, have commenced building an expensive protecting apron across the face of the Falls, and to facilitate the work a temporary side dam has been constructed with a sluice, which carries off the water in rushing rapids, leaving the ridge of the natural fall dry. East of this ridge is an island dividing the main stream from the little fall on the east bank.

"The Mississippi river at this point has a descent of 70 ft. to the mile, and furnishes water power in great abundance. The water is supplied to the mills by canals fed from above the dams, and the tail races for the discharge of the water after it has passed the mill-wheels, are constructed on a novel and ingenious plan. A well or shaft is sunk through the overlying earth and limestone down to the sandstone, and a tunnel is excavated to the river bank below the Falls. The sandstone, it is asserted, yields as readily as sand to the picks of the workmen, and tunnels several hundred feet in length have been constructed. The shaft serves as a water wheel pit. This description, the main points of which are taken from the "Atlantic Monthly" for March, explains the hitherto unintelligible despatch received last summer in reference to the tunnel which was excavating beneath the limestone bed of the Mississippi river below the fall, for the purpose of opening a water power for Nicollet Island. The workmen struck a fissure in the limestone rock, and the Mississippi commenced discharging through the tunnel, and threatened to destroy the Falls of St. Anthony. The vigorous and protracted exertions of the workmen, however, were successful in preventing such a disaster."

THE CLEVELAND LAKE TUNNEL.—Cleveland, Ohio, tired of her nauseous water, is imitating Chicago in the construction of a Lake tunnel, wherewith to obtain the requisite supply of unpolluted liquid. The work—which when completed will consist simply in a shore shaft sunk to the proper depth, a tunnel extending out a mile and a quarter into the lake, and a vertical shaft and crib at the outer end, with inlets for the admission of the water—is being carried on under considerable difficulties. The mining is a tedious process, as there is only space for one man to work. The instrument used is a pick, with a bit nearly as broad as an adze. The clay is so strong and adhesive that by the most vigorous blows of the miner only little fragments are chipped out as large as a man's fist. The work progresses night and day, the miners working by reliefs the entire 24 hours. Not a particle of natural light penetrates that dark cavern, and night and day are the same, the watch being the only means by which to note the flight of time. Next spring the crib will be placed in position, and the outer shaft sunk, so that the work can be carried on simultaneously at both ends of the tunnel.—*American Artisan.*

NEW BOOKS.

OSBURN'S METALLURGY.—The review of this work contained in our March number should have been credited to the "Nation."

AN INTRODUCTION TO SCIENTIFIC CHEMISTRY, DESIGNED FOR THE USE OF SCHOOLS AND CANDIDATES FOR UNIVERSITY MATRICULATION EXAMINATIONS. By S. F. BARFF, M.A., Assistant to Dr. Williamson, Professor of Chemistry, University College, London. Second Edition. London:

Groombridge & Sons, 1869. For sale by Van Nostrand.

This is a well-written text-book on the non-metallic elements, excepting, according to custom, all but a few of the simplest carbon compounds. The four elements, hydrogen, oxygen, nitrogen, and carbon, are first described; then some of their compounds with each other; then the halogen elements and compounds; lastly, sulphur, phosphorus, boron, and silicon. They are described without the use of symbols, which may be an advantage on the whole; but as the value of symbols is so very great when we advance a little in our studies into deeper matters, they have to be learned, and we are not quite sure that it would not be simpler to make use of them from the first. At the same time, there is one important objection to their early use, which is that they are then apt to make the facts they are intended to express less thoroughly appreciated by the student than they would be if he had constantly to come into direct contact with them.

In a second part of the work the author goes over his ground again for the purpose of giving these symbolic expressions, and at the same time extending the treatment of each subject.

The nomenclature adopted is, as we might have expected, that used by Dr. Williamson; it is therefore, in one particular and important instance, not that in general use by other eminent chemists. We refer to the use of the word "acid." The oxides of an element capable of uniting with the oxide of a more basic or electro-positive element are the bodies described in this work as "acids." The more general practice is to call by this name such bodies as the essential ingredient of spirits of salt, aquafortis, vinegar, oil of vitriol, because they *are acid*, as every one admits. Mr. Barff himself, indeed, speaks of "hydric chloride" (hydrochloric acid) as an *acid body* (p. 73). We do not intend, however, to press the point against him; the application of the term is a matter on which distinguished chemists are divided, and for our own part we think that the use of the term with any rigidly fixed signification might well be dispensed with, as it is not really wanted.

As an example of the style in which the work is written, we give a paragraph on the preparation of chlorine for general purposes:—

"Chlorine is usually prepared from one of its compounds called hydric chloride, which contains it united with hydrogen. This body has powerfully acid properties; it turns blue litmus paper to a bright red, and is commonly called hydrochloric acid. Many years ago it was called by chemists muriatic acid, and by common people then, as well as now, spirits of salt, but its correct name is hydric chloride. When hydric chloride is heated with a substance which can take away its hydrogen, chlorine is of course set free. The substance used for this purpose is black oxide of manganese (properly called manganic binoxide), which contains the metal manganese and oxygen. The oxygen of the manganese takes the hydrogen of the hydric chloride and forms water, setting its chlorine free, half of which at the moment of its liberation unites with the manganese, forming manganic chloride, and the other half escapes, and can be collected as free chlorine; 146 grammes of hydric chloride require 87 grammes of manganic binoxide for their decomposition: that is, 146 parts, whatever be the weight of a part adopted—whether grammes, grains, pounds, or ounces—require 87 parts of the same weight for their perdecomposition."

We can only add that we find this little treatise as sound in its treatment of the science as it is clear in its description of the facts, and we are not therefore at all surprised at the success it has already had.—*Scientific Opinion.*

A Treatise on Ore Deposits. By Bernhard von Cotta, Professor of Geology in the Royal School of Mines, Freiberg, Saxony. Translated from the second German edition, by Frederick Prime, Jr., Mining Engineer, revised by the author. 574 pages 8vo, with numerous illustrations. D. Van Nostrand, Publisher.

Professor Bernhard von Cotta, of the Freiberg School of Mines, is the author of the best modern treatise on ore-deposits (*Erzlagerstættenlehre*); and we are heartily glad that this admirable work has been translated and published in this country. The translator, Mr. Frederick Prime, Jr., a graduate of Freiberg, has had in his work the great advantage of a revision by the distinguished author himself, who declares in a prefatory note, that this may be considered as a new edition (the third) of his own book.

The changes in matter are quite numerous, and sufficiently important to make it advisable for those who possess the latest German edition to obtain this also. It is true that many of them are merely omissions; but these are, in some cases, of positive value, as, for instance, where the sections on certain supposed distributions of rich ores in regular zones have been struck out, as no longer supported by facts. We are not so well pleased to miss the chapters on prospecting and tracing ore-deposits, though these were meagre, and the work of Professor Gaetzschmann on that special theme (which by the way, ought to be translated next) is far more satisfactory. On the other hand, much has been altered or added throughout the book, in order to conform it to the latest results of foreign science and experience. As it now stands, it is calculated to do much good in this country, by clearing away a deal of rubbish from the field of this subject, and sowing the seeds of common sense and scientific accuracy.

Mr. Prime's work has been performed, on the whole, with skill and fidelity. We deem it a serious defect in his plan, that he resolved to reproduce merely the treatise of von Cotta. The work could be made more valuable by thorough transformation, and the substitution of American examples and illustrations. We trust that Mr. Prime himself may hereafter be moved to complete the good work he has begun, and really edit, as well as translate, the book before us. It is a stout, healthy stock, and will bear a graft of American science.

We notice some faults of translation, which we shall be so ungracious as to point out, since they can easily be corrected in the subsequent edition, which we hope will soon be called for. They are mainly infelicities or inaccuracies in the substitution of English for German technical terms. Our language scarcely possesses a settled nomenclature of mining, still less of the science of ore-deposits; and in reproducing treatises from so rich a vocabulary as the German, it is necessary frequently to coin new words. But we ought to imitate the Germans in adopting the current miners' terms, wherever it is possible; and certainly we should not misapply terms which have al-

ready a fixed meaning. Mr. Prime's translation of *Drusenraum* (as applied to a cavity or space in a lode, lined with crystals) by *geode* instead of *vug*, strikes us as unfortunate, to say the least. The latter word would exactly express his meaning, while the former more properly describes a nodule or boulder containing such a cavity. We must question also the use of the word *flyccan*, to mean a cross-course, or cross-vein. The universal usage in this country applies this term only to softened, decomposed rock or clay, such as frequently occurs on the walls of veins. On the other hand, little use has been made of numerous American terms, already familiar to our mining population, and often exceedingly appropriate and forcible. Such names as spur, casing, gouge, hill-deposit, cement-deposit, gulch deposit, prospecting, and many others, are worthy to be retained. We confess to an affection even for the humorous and descriptive phrase, to "peter out," as applied to the contraction and final disappearance (*auskeilen*) of a vein. We should prefer width or thickness to breadth, which has been chosen by Mr. Prime to designate this dimension (*Mæchtigkeit*) of a fissure.

But we need scarcely say that these suggestions are not intended to detract from the really sterling value of this treatise. It is a timely and welcome contribution to the literature of mining in this country; and we are grateful to the translator for his enterprise and good judgment in undertaking its preparation, while we recognize with equal cordiality the liberality of the author in granting both permission and assistance. Bernhard von Cotta needs no new laurels from the paths of science; but those which he wears already derive added grace from the genial sympathy with which he extends a hand of help and encouragement to his younger co-laborers and scholars. Every student at the Freiberg school regards with enthusiasm, and every graduate remembers with gratitude, the fraternal interest in his progress manifested by the distinguished men who constitute its corps of instructors; and among them none is more beloved than the brilliant author of the "Gesteinslehre," "Geologische Briefe," "Gangstudien," "Geologie der Gegenwart," and "Erzlager-stættenlehre."—*The Engineering and Mining Journal.*

A Short Course in Qualitative Analysis, with the New Notation. By J. M. Crafts, Prof. of General Chemistry in the Cornell University. 133 pp. 12mo, with 5 Tables. N. Y., 1869. (J. Wiley & Son.) For sale by Van Nostrand.

Prof. Crafts is well known to our readers from his frequent valued chemical contributions. He has, in the small volume before us, attempted the solution of a problem which every chemical instructor must meet whose duties call him to impart to a mixed class of academic students a maximum of knowledge in a minimum of time. A considerable portion of the first two chapters is devoted to an explanation of the theory of chemical reactions and nomenclature. The student is at once inducted into the notions of modern chemistry and familiarized with atomicity and the present chemical nomenclature. It is certain that under a good teacher any faithful student will master the main points of qualitative analysis by the time he has gone through the second part of this useful little volume. Only 34 of the 64 radicals known to chemists are treated of in this book. This brevity sometimes mars symmetry and renders the work of the student almost too simple, as when, for example, strontium is left out of group II. The Tables IV and V, intended to record in a compact form the facts of analytical chemistry, are ingeniously devised by Mr. Perkins, to give the student exact ideas and methodical habits.—*American Journal of Science.*

On Aniline and its Derivatives. A Treatise upon the Manufacture of Aniline and Aniline Colors. By M. Reimann, P.D., L.A.M., to which is added, The Report on the Coloring Matters Derived from Coal Tar, Shown at the French Exhibition, 1867; by Dr. A. W. Hofmann, F.R.S., MM. G. de Laire and Ch. Girard. The whole revised and edited by William Crookes, F.R.S., &c. 8vo, pp. 164. (John Wiley & Son, Astor Place, New York, 1868. For sale by Van Nostrand.

Dr. Reimann's account of aniline and its derivatives is a fine example of the union of exact science with practical skill, and, as such, teaches an important lesson beyond its special theme. It could not have had a more valuable supplement than in the admirable report of Dr. Hofmann and his associates, on the coal tar colors shown at the French Exhibition of 1867. The book, though published by Messrs. Wiley, was printed in London, by Mr. Crookes at the office of the "Chemical News."—*American Journal of Science.*

Exercises in Practical Chemistry. By A. G. Vernon Harcourt, M.A., F.R.S., Sec. C. S., and H. G. Madan, M.A., F.C.S. Series 1st, Qualitative Exercises. 335 pp. 12mo. Oxford, at the Clarendon Press, 1869. London: Macmillan & Co. For sale by Van Nostrand.

This little volume is designed as the beginner's *vade mecum* in commencing the study of practical chemistry in the laboratory. No attempt at a systematic presentation of the elements of the science is here made. The novitiate is presumed to be equally innocent of nomenclature, symbols and philosophy, and is led into the laboratory much as an apprentice to a trade, and is therefore first made familiar with his tools, and how to use them in the most simple operations before even attempting the preparation of oxygen and other gases. It is illustrated by 65 wood-cuts, mostly new and many of them very effective. The nomenclature is that of Williamson. Symbols expressing the more important reactions are given at the foot of the pages where needed. We look with interest for the second series on quantitative chemistry.—*American Journal of Science.*

Civil Engineering and Public Works.—Paris Exposition of 1867. By Wm. P. Blake, Commissioner of the State of California. Washington: General Printing Office. For sale by Van Nostrand.

This is the title of a report published in the series of reports of the United States Commissioners to the Paris Universal Exposition of 1867. It is an octavo of some fifty pages prepared by Prof. William P. Blake, Commissioner of the State of California, and contains interesting notices of the extent of the exhibition made in that class; of materials for construction; a description in detail of the Chicago Lake Water Tunnel, illustrated by two plates; a description of the Suez Maritime Canal, and other miscellaneous notices.

ANNUAL OF SCIENTIFIC DISCOVERY, OR YEAR-BOOK OF FACTS IN SCIENCE AND ART FOR 1870. Edited by JOHN TROWBRIDGE, S. B., Assistant Professor of Physics in the Massachusetts Institute of Technology, aided by SAMUEL KNEELAND, M. D., Professor of Zoology and Physiology in the Institute and W. R. NICHOLS, Graduate of the Institute. Boston: Gould & Lincoln. For sale by Van Nostrand.

The "Annual" has so far become a necessity to the general scientific reader that the bare announcement of its appearance is sufficient to insure a lively demand for it. The present volume is embellished with a fine portrait of Prof. Peirce, the Superintendent of the Coast Survey.

MISCELLANEOUS.

SOLUTIONS FOR HARDENING STEEL.—A page might be filled with the record of all the preparations, mixtures, charms, etc., by the use of which success in the tempering of steel has been attempted, and each of which has had its admirers.

A certain virtue has been, by many, supposed to reside in leather shavings, by which, if a tempering fire *be kindled* with them, immunity from cracking is secured; and Byrne states that a man who had tried it told him that, although before its use he was greatly troubled by cracking while tempering, since he had found out the virtues of leather as a preventive not a single case of cracking had occurred, though he had used it for years.

Argument, of course, would be useless with such an individual; his experience (*sic*) would weigh with him more than anything that could be said by any one else, though the experience of the latter might have shown the utter worthlessness of the article in which the former placed blind and implicit faith.

The state of things which we have described is scarcely to be wondered at, when we reflect that all knowledge on the subject of hardening and tempering steel is empirical. Nothing is accurately known about it except that when steel is heated and suddenly cooled it becomes hard and brittle, and that by heating it again its hardness and brittleness may be reduced to the degree required, and that this change of character is a molecular change of some kind yet to be determined.

The suddenness of the cooling is of course affected by the rapidity with which the cooling medium conducts or conveys away heat; and any change in the character of the medium which does not increase or diminish its conducting power would certainly seem to have little to support it. Of course, the character of the objects to be tempered will indicate in some measure the mode employed. The watchmaker often heats his tiny drills in the flame of a candle, hardens them by sticking them into the cold tallow, and draws the temper by the same flame.

A little salt thrown into the water employed for tempering is quite generally supposed to add to its virtues, but a competent experimenter informs us that in a large number of experiments instituted to test the truth or falsehood of this notion, he found nothing to support it.

Thin and small objects, which only need a small degree of hardness, may be advantageously hardened in oil, for the reason that it cools them less suddenly, and therefore does not make them so hard as water would, while for large articles requiring to be very hard, quicksilver has been employed with success for precisely the opposite reason.

A recipe for hardening mill picks, which, slightly varied in its proportions, has quite a reputation, is as follws: 2 gallons rain water, 1 ounce corrosive sublimate, 1 ounce sal-ammoniac, 1 ounce saltpetre, and 1½ pints of rock salt. The picks to be heated to a cherry red and hardened, and the temper not to be drawn. It is claimed that the salt gives hardness, and the other ingredients toughness to the picks; but no reason why they should do so seems tenable, as there certainly is no chemical reaction in the bath by which these results can be accounted for.

We hazard the opinion that simple water would be just as good, and that for all moderately sized articles it is just as good as any solution that can be made, though of course in a matter depending so much upon personal judgment as the hardening and tempering steel, we should not expect any man to succeed perfectly at first with any bath to which he had not become accustomed.—*Scientific American.*

PUNCHING METALS.—General Morin presented to the Academy of Sciences of Paris, at their session of January 3d, a paper upon the punching of metals and plastic materials. He says:

We have proven by the results of numerous experiments in punching, made upon lead, that the characteristic co-efficient of pressure per square metre is exactly equal to the resistance to shearing per square metre; and from this theory we have deduced the formula,

$$L = R_1\left(1 + \log^1 \frac{R}{R_1}\right)$$

in which R is the radius of a cylindrical block,
R_1 " " the punch,
L the length of "

This geometrical function contains no term depending on the height of the block, and in this general form no hypothesis as to the nature of the material is implied. This circumstance attracted the attention of the committee to whom our previous memoir was referred: and before it could be finally asserted that the kind of material has no influence upon the length of the punching, it was necessary to make a series of experiments upon different substances, in order to be assured that the lengths L would in every case confirm the numerical value obtained from the formula. We have experimented upon modelling wax, ceramic paste (wet and dry), tin, copper, and iron. The experiments were twenty-six in number.

In order to compare the results, we represented upon one figure all the ratios $\frac{L}{R}$, taking for abscissas the several values of $\frac{R}{R_1}$. The theoretic curve, whose equation is

$$\frac{L}{R_1} = + \log^1 \frac{R}{R_1},$$

was drawn to the same scale, so that it could be seen at a glance how the values $\frac{L}{R_1}$ agreed. This method, without exception, establishes the conclusion, that for all materials that can be punched, and in all cases in which the block is not so thin

that the punching reduces to a simple cleavage, the length of the punching is actually given by the theoretic formula, and the *a posteriori* verification allows us to affirm, with renewed confidence, all the principles of our theory of the deformation of solid bodies.

The measure of force necessary to effect the various punchings easily gives the value of the resistance to shearing, in case of the ordinary metals. This resistance (per square metre) is determined to be, for

Lead....................	1,820,000 kil.
Block tin...............	2,090,000 "
Alloy of lead and tin.....	3,390,000 "
Zinc....................	9,000,000 "
Copper..................	18,930,000 "
Iron....................	37,570,000 "

—*Les Mondes.*

Zinc-white.—Within a very few years, zinc-white, or oxide of zinc, has become a favorite basis for a white pigment, and in many respects it has advantages over even the best white lead. For inside work and for localities whose atmosphere is more or less infected with sulphuretted hydrogen, it answers admirably well. In all respects it is certainly far superior to the highly adulterated white lead with which our markets are so abundantly stocked. Its use as a pigment in connection with any preparation of lead is, however, strongly to be deprecated, and the best way of applying it, according to Dr. Dingler, is the following: The ordinary boiled linseed oil should be substituted in the mixing operation by one prepared by gently boiling 200 lbs. of the raw oil for 5 or 6 hours, then adding about 24 lbs. of coarsely broken lumps of binoxide of manganese, and continuing the boiling operation for about 10 hours longer. In such a manner a very quickly-drying linseed oil is obtained, which is eminently fit for the purpose of being used with zinc-white and other zinc colors. The Doctor lays stress upon the use of old linseed oil, and also upon the care to be taken with the boiled oil, which, unless carefully kept from access of air, becomes thick in a very short time. The boiled oil so prepared ought not to be used in painting with zinc-white by itself alone, but should be mixed, in quantities of from 3 to 5 per cent., with the raw linseed oil used to mix up the paint.

The Use of Manganese Compounds in glass manufacture is one of the earliest applications of this element; but the fact that glass which has been bleached by it afterwards undergoes a marked change, and in the course of a few months has entirely different optical properties, is not generally known. The oxide of manganese is put in to counteract the effect of oxides of iron, but, in course of time, the oxide is acted upon by the light and air, and colors the glass red. Many a photographer has been puzzled to know why the glass of his skylight no longer lets light through so as to give him good pictures, and many a gardener has been troubled by the parched appearance of the grape vines in his conservatory, and by the decrease in the yield of grapes; both of these phenomena are due to the fact of the presence of manganese in the glass and the consequent red color. Red glass will not permit any chemical rays to pass, and hence the photographer can take no pictures. The same color will let heat through to parch and dry the vines, but the life-giving rays are cut off. Thus, as our knowledge increases, we must order our glass to be made according to the laws of light, as well as of chemistry.

Ocean Telegraphs.—The "Times" gives the following tabular statement of the ocean telegraphs now constructed or contracted for, and of the sums used or subscribed to complete them. Irrespectively of some short cables in the seas of Northern Europe, the list is as follows:

Name of Company, etc.	Capital.	Length of Cable.	When Contract was or is to be Completed.	Date of forming of Company.
		Miles.		
Anglo-American Telegraph Company ...... (Two Cables, Valencia to Newfoundland)......	£1,860,000 ('65) 600,000 ('66)	1,898 1,852	September, 1865... July 27, 1866...	March, 1865.
French Atlantic Telegraph Company, (Brest to Boston)............	1,200,000	1,333	July 20, 1869..	July, 1868.
Falmouth, Gibraltar and Malta Telegraph Company............	660,000	2,456	May 31, 1870...	July, 1869.
Anglo-Mediterranean Telegraph Company (Malta to Alexandria)............	260,000	900	October, 1868..	May, 1868.
British-Indian Telegraph Company (Suez to Bombay)............	1,200,000	3,600	April, 1870...	January, 1869.
British-Indian Extension Company (Ceylon to Penang and Singapore)............	460,000	1,756	Before end of 1870	October, 1869.
China Submarine Telegraph Company (Singapore to Hongkong and Shanghai)......	525,000	2,640	June 1871...	December 10, 1869.
British-Australian Telegraph Company (Singapore to Java and Port Darwin).........	660,000	1,726, 800 land	Before end of 1871	January, 1870.
Total capitals..................	6,925,000	20,961 —	Total miles.	

Oil of Vitriol.—A new method for effecting the concentration of oil of vitriol—the invention of M. Cotelle—is thus described in the "Journal de Pharmacie et Chimie." A column lined inside with fire-bricks and made outside of good ordinary bricks, rests on a large pedestal. This column is open at both top and bottom, but in these openings are fitted fire-clay stoppers. The inside is fitted with calcined pumice-stone; inside the lower portion, openings are made between the bricks,

through which a current of highly heated air is forced. From the top, the acid to be concentrated is made to trickle on the pumice-stone, and meeting with a current of highly-heated air, the superfluous water is driven off, and the acid, on arriving at the bottom, is in a concentrated state, and runs off in properly arranged vessels.

NATIONAL PROGRESS.—We give below an interesting table appended by Mr. Vignoles to the admirable address delivered by him before the Institution of Civil Engineers.

STATISTICS.

1868–69.	United Kingdom.	France.	Prussia.	Spain.	United States of North America.
Railways (English miles)	14,247	10,302	5,603	3,331	42,572
Metalled roads (English miles)	160,000	100,048	55 818	10,886	
Navigable rivers (do.)	....	6,015			
Canals (do.)	3,000	3,154			
Telegraph lines (do.)	22,165	23,830	13,881	6,922	
Telegraph wires (do.)	96,104	67,473	45,708	15,263	99,099
Telegraph stations (number)	2,482	1,701	830	184	
Post offices (number)	17,741	5,099	8,942	....	25,200
Letters (number yearly)	808,118,000	537,099,358	270,000,000	....	631,010,000
Newspapers and book packets (number yearly)	105,845,000	351,076,008			
Area (square English miles)	122,519	210,460	139,675	198,061	8,591,849
Population (number)	30,621,431	38,192,064	23,970,941	15,673,481	38,442,995

—*Engineering.*

THE REMOVAL OF BLOSSOM ROCK IN SAN FRANCISCO HARBOR.—The progress of perhaps one of the grandest engineering enterprises that has ever been conceived on the Pacific coast—the destruction of Blossom Rock—is rapid and steady. Our reporter visited the scene of operations on Sunday, and was courteously shown through the works by the gentleman in charge. The wooden structure which bears the engine and the shanty where a portion of the workmen reside has been so firmly secured to the rock and anchored on the outside that the high winds and swell on the bay have not affected it in the least, the water rushing though the open work beneath, with, even in the hardest gales, no perceptible vibrations to the occupants of this isolated dwelling. There are 16 men employed at present on the rock those engaged on the excavations below being practical and experienced miners. After being first provided with an oil-skin cap and sou'wester, the visitor descends the ladder placed on the side of the iron coffer dam, and, when stepping from the last round to the centre, from which the tunnels branch off, he finds himself 40 ft. below the level of the surface of the water. An iron pipe leads down to this well, through which the water resulting from the leakage of the shell of the rock is pumped up, and also a large tub and rope for the removal of the rock, both being worked by the engine on the scaffolding above. Here is a perfect network of tunnels branching off in every direction, and supported by the natural columns which are allowed for a short time to remain, but gradually replaced by powerful wooden stanchions. It is calculated that when the explosion takes place a small portion of the rock which may not be thrown upward or outward will fall back into the cavity, and therefore the rock has been excavated 9 ft. below the level required in the contract, and the columns are removed to make as much room as possible for the reception of this matter in the original shell. As the tubs of rock and rubbish are hauled up and dumped into the tide, the strength of the currents is sufficient to carry them off and distribute them so equally, as it were, that as yet, from the soundings, the mass has risen but 1 ft. above the natural level.

The area of Blossom Rock is 5,000 cubic yards, and 500 cubic yards have already been removed, a half yard being taken up in each tub. When the destruction of the rock was attempted by the Government by means of bursting torpedoes overhead, they succeeded only in cracking and perforating the rock, but not in displacing or separating any of the particles. In consequence of this, these portions of the rock where the experiments have been tried are so leaky that the workmen find its removal difficult. When tunnels have been excavated as far as possible toward the outward shell, twenty tons of powder will. inclosed in tight wooden casks, be distributed through these tunnels, the wire passing through all, and connected with a battery some quarter of a mile distant, so that the explosion must necessarily be simultaneous. The water will then be allowed to rush into and fill the coffer dam with an enormous pressure. There is but little doubt that the total annihilation of this dangerous obstruction to the freedom and safety of our harbor will be the result of the grand blast to come off about the middle of March. The residents on the rock have two pets which have become quite domesticated and attached to them. One is a seal, who paddles about the scaffolding all day, and appears to regard with interest the operations of the dumping machine; the other is a rat, who made the trip to the rock in a bag of coal, and who comes to the door of the shanty regularly at meal times. The latter animal is considered a lucky omen, for as rats never remain in a leaky vessel, the men feel quite secure in their house on the water, and say that when the hour of departure arrives the rat shall not be left to perish, but shall be safely landed on the wharf, to relate to his brother rats his experience on Blossom Rock. and the hospitable manner in which he was treated by their sworn enemies.—*San Francisco Bulletin.*

Determination of the Mean Annual Temperature. —Mr. Henry Lucas, in "Les Mondes," writes:

Forty years of observation have convinced me that a sufficiently exact determination of the mean temperature can be obtained by a single daily observation of the thermometer.

Let the temperature be noted at 8 o'clock in the evening, by a good thermometer, divided to $\frac{1}{5}$ or $\frac{1}{10}$ of a degree, properly hung, and it will be found that the annual temperature so obtained will agree almost exactly with that determined by making three observations in a day; and, besides, that the monthly averages are quite correct. The months of March and April, during 32 years' observations, give a difference of only 0.2 of a degree; for the other months the difference is $\frac{1}{10}$ of a degree and less. The monthly variations agree in this: that while the mean annual temperature calculated from observations at 8 o'clock in the evening, during 23 years, is 6 deg. 40 R., that which is deduced from three observations a day is 6 deg. 42 R.; a difference which is quite insignificant.

The observation of the thermometer at 8 in the evening has this great advantage over observations made at 6 A. M. and 2 P. M., that the effect of reflected heat is avoided.

The following table gives the mean temperature of 40 years' observations at 8 o'clock P. M., compared with the mean of temperatures observed at 8 A. M., 2 P. M., and 8 P. M.:

	8 P. M.		8, 2 & 8		Difference.
1823 to 1832..	6° 54 R.	..	6° 61 R.	..	0° 07
1833 " 1842..	6 54	..	6 54	..	0 00
1843 " 1852..	6 30	..	6 42	..	0 12
1853 " 1862..	6 17	..	6 20	..	0 03
Mean......	6 39	..	5 44	..	0 05

Brandes, at Sazflau, from hourly observations during a year, gets a mean of 8 deg. 55 R.; from daily, at 8 P. M., a mean of 7 deg. 62. Kupffer, from 6 years of observations obtains a mean of 3 deg. 08 R.; from daily, at 8, a mean of 3 deg. 20. 11 years, at Schwerin, give a mean of 6 deg. 52; from daily observation at 8, a mean of 6 deg. 43.

Dualin.—This compound, which, according to its inventor, Mr. Dittmar, possesses the explosive power of nitro-glycerine, together with the slow combustibility of ordinary gunpowder, consists principally of nitrate of ammonia and fine sawdust, that has been acted upon by nitro-sulphuric acid. This material, according to Fuchs, is undoubtedly endowed with a greater explosive force than ordinary powder; it is also considered as being less dangerous in regard to spontaneous explosion. In its composition it is similar to that of gun-cotton, being also subject to gradual decomposition in moist air. In regard to the efficacy of the dualin, as compared with dynamite (which is a mixture of nitro-glycerine and infusorial sand), the inventor states that they are both equal in this respect. However, it is extremely difficult to get at comparable results in blasting experiments; in most instances, the experimenter must be satisfied with the average results of a great number of trials undertaken under various conditions. But it is nevertheless easy, in one respect, to fix a difference between the two materials, which leaves no doubt as to the superiority of the dynamite. If equal quantities of dynamite and dualin, provided with primers, are allowed to explode upon air plates of equal strength, the effect indicates such an evident difference, that one must adjudge to the former a much more rapid and violent action. This will certainly be recognized in blasting rocks. In price dualin is cheaper than dynamite. When coming in contact with fire, it will certainly cause explosion, as it burns quite as rapidly as ordinary powder. Of the dynamite, however, it is sufficiently established that it will never explode on holding a flame near it, but simply burn quietly, even if inclosed in strong wooden boxes. Against pressure and concussions, both blasting materials are equally inert, and, finally, dualin possesses the advantage over dynamite that it does not freeze, while the latter, when in a frozen state, cannot be directly exploded. But as blasting is mosly suspended during frost, this circumstance is not of very great importance; moreover, the use of dynamite is not excluded at all, if frozen, as it will readily yield by the explosion of a small cartridge containing non-solidified dynamite. The great superiority of dynamite, above all, consists in its non-liability to become moist; this property allows its direct application under water and in bore-holes, while dualin, like gunpowder, does not bear contact with water.—*Journal of Applied Chemistry.*

Telegraphic Communication with Australia. —An apparently sound scheme for bringing the Australian colonies into telegraphic communication with the mother country has been introduced this week. It is to be styled the British Australian Telegraph Company (Limited), and is created in connection with the five companies by which the various sections that will constitute the great through line from England to the East have already been put in active progress. The present work is to consist of a cable of 563 miles from Singapore to Batavia, to join the Dutch lines which run to the south-eastern extremity of Java, whence another cable of 1,163 miles will be laid to Port Darwin in Australia, where a land line of 800 miles will connect the system with Queensland, New South Wales, Victoria, South Australia, Western Australia, and Tasmania. The capital is to be £660,000, in shares of £10, and the making of the entire lines is to be confined to the Telegraph Construction and Maintenance Company, at the contract price of £634,000, of which £120,000 is to be in paid up shares. The Falmouth and Malta, the Anglo-Mediterranean, the British Indian, and the British Indian Extension Companies are to allow the same rebate upon their through rates on all messages forwarded over their route by this company as they have granted to the China Submarine Company, thus creating a reciprocity of interests calculated to operate as a strong inducement to the harmonions working of all. According to the prospectus, the estimate of profit, reckoning 25 daily messages from the Dutch islands, and but 65 from the whole of the Australian colonies, is £121,665, or about 18 per cent. per annum, exclusive of local and Chinese traffic, and should this be steadily realized it may be hoped the directors will have the wisdom thenceforth to preclude all chance of future competition by giving their customers the benefit of a constant reduction in charges in proportion as any increased success may be attained.—*Engineering.*

Liverpool to Bombay, *via* the Suez Canal.— At present the public and also commercial men are anxious to know the real value of the

Suez Canal, either in a financial point of view or in the saving of time in the transmission of goods between England and Bombay. The following figures, which have been compiled by one of the officials connected with the Liverpool Chamber of Commerce, will be read with considerable interest. From this statement it appears that at the opening of the canal last year, the rate of freights from Liverpool to Bombay, *via* the canal, was 80s. per ton, but at the present time freights by the same route do not exceed 30s. per ton, overland rates being about the same. No sailing vessels, it appears, convey goods either *via* the Suez Canal or overland route, and the following quotations are consequently for steamers alone: Sailing vessels.—Average duration of voyage to India—*via* Cape of Good Hope, 95 days; *via* overland route, 43 days; *via* Suez Canal, 38 days; to the United States, 40 days. Steam vessels.—Average duration of voyage to India—*via* Cape of Good Hope, 60 days; *via* overland route, 43 days; *via* Suez Canal, 38 days; to the United States, 12 days. Sailing vessels.—Average rate of freight per ton to India—*via* Cape of Good Hope, 35s.; *via* overland route, 80s.; *via* Suez Canal, 40s.; to the United States, 10s. Steam vessels.—Average rate of freight per ton to India *via* Cape of Good Hope, 60s.; *via* overland route, 80s.; *via* Suez Canal, 40s.; to the United States, 30s.—*Liverpool Albion.*

EMERY.—The quantity of emery used in this country, already very large, is increasing annually. One house in Boston, D. Webster King & Co., of 51 Kilby street, sells the entire product of one factory, which turns out about 1 ton per day. The main building is 60x30 ft. and 3 stories high, with an ell attached 50x30 ft. Here are employed about 12 men in the manufacture of Smyrna emery from the pure Turkish stone. The different grades are 24 in number, and to produce these the stone has to pass through a large number of crushers, rollers, bolts, cleansers, etc. Four large elevators run from the ground floor to the 3d story, besides several other smaller ones. The finest grade of emery is produced by what is called a blower, which was devised by the company. This grade, which is called the flour of emery, floats in the air in a large room through the day, and when work in the mill ceases over night it becomes settled. The great advantage which this company claim over all others is their machinery, which gives a perfect grading, and cleanses the same in the very best manner. The company are constantly receiving this stone from Turkey. For polishing hard minerals and metals it has no equal. It is a subspecies of rhomboidal corundum, and occurs in massive and also in granular concretions. Its color is between grayish black and bluish gray, and when powdered it has a reddish hue. It is so very hard as to scratch topaz, its constituents being alumina, silica, and iron. The mill has been in operation 3 years. The company have now a capital of $200,000, and are doing a thriving business. D. Webster King & Co., 51 Kilby street, Boston, are agents for the company.—*Chicago Railway Times.*

THE WATER SUPPLIES OF LONDON AND PARIS.—The quantity of water supplied daily to the metropolis during the year has ranged from 91,578,341 gallons, in the month of January, to 110,094,058 gallons, in the month of July; the average for the whole year being, as nearly as possible, 92,000,000 of gallons daily; and the average number of houses supplied has been 466,100. This is at the average rate of 29 gallons per head of the population daily. About half of the supply is from the Thames, and the rest is from the River Lea and from springs and wells in the chalk. According to the official returns from the Prefect of the Seine, the average daily supply of water to Paris during the year has been 46,858,900 gallons, which is at the rate of 24.8 gallons per head of the population; but this includes the supply to the public fountains and to the ornamental waters in the Bois de Vincennes, the Bois de Boulogne, and elsewhere. The water is derived from the Seine, the Marne, the Canal d'Ourcq, and from artesian wells and springs in the chalk. None of the river water is filtered, and it is always turbid.—*Engineering.*

SPECTRUM OF THE FIRE-FLY.—Professor C. A. Young says this is "perfectly continuous, without trace of either bright or dark lines, and extends from a little above Fraunhofer's line C, in the scarlet, to about F in the blue, gradually fading out at the extremities. It is noticeable that precisely this portion of the spectrum is composed of rays, which, while they more powerfully than any other affect the organs of vision, produce hardly any thermal or actinic effect. In other words, very little of the energy expended in the flash of the fire-fly is wasted. It is quite different with our artificial modes of illumination. In the case of an ordinary gas-light, the best experiments show that not more than one or two per cent. of the radiant energy consists of *visible rays*; the rest is either invisible heat or actinism; that is to say, over ninety-eight per cent. of the gas is wasted in producing rays that do not help in making objects visible."

EJECTOR CONDENSERS.—The most important improvement that has lately been made on steam engines in general, is the introduction of apparatus whereby the combined impetus of the currents of exhaust steam and of injection water is made use of to eject the product of condensation, and so to supersede the air-pump, well-known to be one of the most troublesome parts of the steam-engine. This enables condensation to be used in many engines in which it was never applied before: such, for example, as the small separate engines now often used in factories to drive various machines, instead of the former system of transmitting power by lines of shafting; and it possibly may have ultimately the effect of putting an end to the use of non-condensing engines, except where the exhaust steam is needed in order to produce a blast.—*W. J. M. Rankine.*

MELENE AS A LUBRICATOR.—An insuperable difficulty attending the use of ordinary lubricators, is their decomposition at high temperatures, leaving behind a thick viscid coating which, especially in cylinders, interferes considerably with the motion it should assist. Ericsson's hot-air engine is especially difficult to lubricate, from this cause. The use of "melene" is advised for this purpose; it being a substance obtained from the paraffines, insoluble in water, soluble in the fixed oils, volatile without decomposition, not boiling under 370 deg., of the consistency of wax at ordinary temperatures, and floating on the surface of cold water. It is cheap enough to be used on a large scale, and preserves from oxidation and adhesion.

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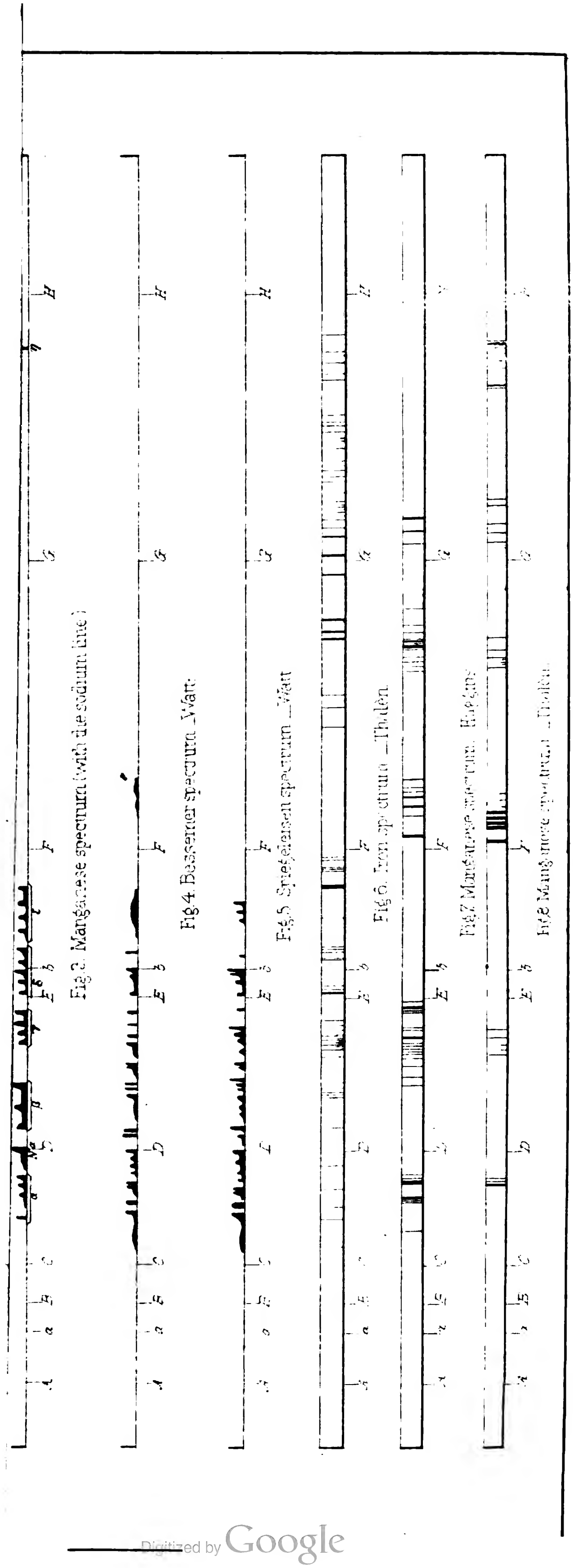

Fig 3. Manganese spectrum (with the sodium line)
Fig 4. Bessemer spectrum _Watt
Fig 5. Spiegeleisen spectrum _Watt
Fig 6. Iron spectrum _Thalén
Fig 7. Manganese spectrum _Huggins
Fig 8. Manganese spectrum _Thalén

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THE SPECTRUM OF THE BESSEMER FLAME.

(Dr. H. Wedding.—Preus. Ztschft., Bd. XVII., 2to Zlef.)

Translated By E. F. Eurich.

In the puddling furnace, the chemical reactions necessary to produce iron require several hours, whereas in the Bessemer process they only occupy from 20 to 40 minutes. From this it follows that a small difference in the duration of the process would change the character of the Bessemer metal more than that of the iron obtained by puddling. In the former process it is, moreover, much more difficult than in the latter to determine exactly when the metal has reached the desired composition, *i. e.*, contains only a certain amount of carbon. On this account, the more rational and cheaper method of producing Bessemer metal directly has been mostly abandoned, it being considered preferable to decarbonize the pig-iron completely, and then to bring it back to the state of steel by the addition of a certain amount of pig-iron, rich in carbon (generally spiegeleisen).

On account of the difficulty in directly observing with the naked eye the reactions of the metal during the Bessemer process, other indications for judging of the state of the reaction had to be sought. Samples taken with a ladle, or by means of an iron bar, give a good insight into the character of the product, and on this account are employed in some places (Styria, Westphalia). On the one hand, however, they are apt to exercise a disturbing influence on the process, and on the other, too much time is required before the operator is able to arrive at a satisfactory conclusion. Since, in consequence of influence beyond control, the duration of the period of reaction is scarcely ever exactly the same in any two operations, the determination of the time required for one operation would be of little benefit for determining the time required for other operations. We are therefore confined to observing the stream of gas issuing from the mouth of the converter, and of the solid particles contained in it, and torn along by it. Fortunately, the color and brightness of the stream of gas furnishes an indication for easily determining the period of total decarbonization, especially if only steel is to be made. When, however, the quality of the pig-iron to be worked varies, or certain qualities of steel are to be produced, whose carbon can only vary within narrow limits, a great deal of practice is necessary for conducting the process by the appearance of the flame, and even then mistakes occur quite frequently. Even under the direction of a skilful engineer, and with qualities of pig-iron whose behavior is known, variations in the quality of the product are not to be avoided. Though these variations do little harm in most cases—for instance, in the manufacture of

the lower qualities of steel for rails, or when the establishment has orders for articles requiring different grades of steel —yet the capability of the general application of the Bessemer process would be greatly increased, if signs clear, unerring, and independent of personal experience, could be discovered to mark the end of the reaction.

Since the flame in itself furnishes us characteristic indications, we may reasonably expect to attain our object by artificially intensifying these indications.

We have already remarked that the guide for determining the point for interrupting the process in order to add pig-iron, is the brightness and color of the flame. It was this last which, in consideration of the chemical reactions taking place in the converter, first drew attention to the application of the spectroscope to the Bessemer process.

Application of Spectral Analysis.—Wm. Bragg, of Sheffield, first suggested the use of spectral analysis for this purpose, and in consequence Prof. Roscoe was, in 1862, induced to make experiments at Brown's Works in Sheffield. In 1863 Roscoe published his first observations of the Bessemer flame. According to these the spectrum of the flame was sufficiently characteristic, and marked the various stages of the process with enough distinctness to give promise of its practical application. In the following year he announced to the Royal Institution that the spectroscope had been practically introduced into Brown's Works in Sheffield for correctly determining the point of decarbonization. Shortly after this time, the spectroscope is reported to have been used at Crewe, and from there it is said to have been taken to Seraing, in Belgium, in 1865.

When operations were commenced with the Bessemer process at the "Königshütte," in Upper Silesia, in 1865, experiments were at once begun with the spectroscope. The instrument was manufactured by a celebrated Berlin firm, yet the experiments were a complete failure. Only a continuous spectrum was obtained, and even the inevitable sodium line only appeared once in a while. Since the instrument was not considered unfit for the work, and since an experiment with carbonic oxide gas (to whose agency the lines in the spectrum were ascribed) gave no better results, the failure was ascribed to the operation itself.

In Austria, Prof. Zielegg followed up this subject with the greatest perseverance. His articles in the reports of the Imperial Academy of Sciences, give exact and trustworthy accounts of the varying character of the Bessemer spectrum during the different stages of the process. His examinations were made at Gratz, where the spectroscope was soon after used uninterruptedly with great success in controlling the Bessemer process. From there the spectroscope was taken to Ternitz, in Lower Austria, and to the "Maximilianshütte," in Bavaria. But at the same time the favorable results obtained at these works were not at all confirmed by experiments tried in other establishments, as at Neuberg, or received only a partial confirmation, as at Hörde.

Immediately after the publication of Prof. Zielegg's articles on the subject, experiments were renewed at the "Königshütte." In the mean time doubts had arisen as to the adaptation of the spectroscope first used, and a new one was obtained from the same firm which had furnished the one at Gratz—Messrs. Kammerer & Starke, in Vienna. This new series of experiments at the "Königshütte" gave results which seem to have met with general confirmation. It was found that the spectroscope could only be satisfactorily employed when the decarbonization was carried on to the point known in practice as that of total decarbonization, and with so-called "cold charges," *i. e.*, with charges pretty free of smoke. In the latter case the end of the reaction can be determined with great accuracy, even by an inexperienced person. For interrupting the decarbonization sooner, there is a lack of reliable indications. If the charges are hot, *i. e.*, have a great deal of smoke, the indications in the spectroscope which are to guide the operator are uncertain, and frequently are entirely wanting. In this case the lines whose disappearance is to indicate the correct point of time for ending the process, disappear too soon.

Explanation of the Spectrum.—Ever since Roscoe's examinations, a scientific explanation of the characteristic appearances of the spectrum of the Bessemer flame has been sought. It was thought to admit of little doubt that carbon, or some combi-

nation of carbon (carbonic oxide), played an important part in it. Comparative, but fruitless experiments were first made by Watt. Zielegg then followed with his thorough investigations. Both sought an explanation for the deviation of the Bessemer spectrum from the spectrum due to carbon, with which they compared it—not in the circumstance that the former was no carbon spectrum, but in the different conditions of its formation.

Brunnerfeist first called attention to the doubtfulness of this conclusion, and pointed out that the spectrum might be mainly due to manganese and iron, and not to carbon. From this a contest arose (not always remaining within the bounds of scientific research), which was carried on in the "Oest. Ztschft für Bguird Hist. Weser," and did a great deal towards clearing up matters. This subject was followed up at the "Königshütte," by Hasenöhel, and at the laboratory of the Mining Academy (Berlin), by Dr. Wiechmann and the author, and the experiments led to the confirmation of Brunner's views. These last were furthermore directly proven by a comparison of the manganese and Bessemer spectra in the same spectral apparatus, by Av. Lichtenfels, at Neuberg.

Thus this interesting subject has in one sense been brought to a close, and this will justify a critical examination of the work accomplished, for the purpose of gaining a secure foundation for future investigation. From henceforth investigation will have a different direction, but at the same time it promises results not the less interesting from the scientific or important from the technological point of view.

CONCLUSIONS AS TO THE SPECTRUM OF THE BESSEMER FLAME.

The character of the Bessemer flame, as it presents itself to the naked eye, in connection with the chemical reactions which take place in the converter during the process, permits us to draw certain preliminary conclusions as to the spectrum seen in the spectroscope.

Exterior Appearance of the Bessemer Flame.—At the commencement of the process no real flame appears, but only an illumined stream of gas containing numerous reddish sparks, which are mostly little pellets of iron. After a few minutes an orange-colored flame, of low luminous power and transparent, is formed; a few blue stripes appear in it and a whitish border is now and then seen on its edge. Gradually sparks of burnt iron and fragments of white hot slag are mixed with it; its brilliancy is increased, and the stream of gas, at first steady, becomes irregular and fitful. In the second period the flame is very bright, almost white; is very luminous, and contains numerous sparks of iron and pellets of slag which are sometimes ejected in a sheaf-like shape. A violent, restless flickering of the stream of gas only decreases at the end of the period, while the flame is brightest. With the commencement of the third period the eruptions become less frequent, without a diminution in the luminous power of the flame. After a few minutes, however, this becomes weaker, and the flame appears more transparent and contains blue and violet colors palpably intermixed. Only in the working of certain qualities of pig-iron (dark gray manganiferous iron) does the flame remain strongly luminous till the end of the charge (for instance, at Hörde). At the close of this period the flame suddenly ceases, and a transparent stream of gas, illuminated from within, is steadily expelled out of the mouth of the converter. At this point the process is interrupted. In the second period, and with some qualities of iron (especially if taken directly from the blast furnace), even in the first, the flame is mixed in a greater or less degree with a brown smoke, more seldom with a whitish or yellowish smoke. In the last period this smoke quite frequently appears in such quantities (as, for instance, at Königshütte) that even the existence of a flame can be scarcely observed. In this case it is of course very difficult to determine the time of the disappearance of the flame.

With the addition of the spiegeleisen, for the purpose of bringing the decarbonized iron back to steel, and if the blast at the same time be shut off, we notice an orange-yellow sooty flame, which, on again admitting the blast, changes into a flame resembling in color and appearance that at the commencement.

Chemical Reactions.—In the first period (the period of slag formation, or the firing period), the greatest part of the silicon contained in the pig-iron is oxidized by the oxygen of the blast, and in con-

junction with protoxide of iron and protoxide of manganese forms a slag, into which also enter silica, alumina, lime, magnesia, and alkali, from the lining of the converter. In the second period (the boiling or eruption period), the slag which has become a proto-silicate, takes up FeO, Fe_2O_3, and this acts decarbonizing on the pig-iron, with the formation of carbonic oxide, and probably also of carbonic acid. The calculated quality of oxygen in the blast seems at least to point to this last. The decarbonization of the iron is continued in the last period, until the desired degree of decarbonization has been reached, when the process is stopped. On the addition of spiegeleisen, which now takes place, there is partly only a mixture of the last with the decarbonized iron, and partly a chemical reaction takes place between the oxygen contained chemically, or mechanically, in the latter, and the carbon, silicon, manganese, etc., contained in the former. The whole process can therefore be traced back to an oxidation. Of the products of this oxidation, the carbon combinations (carbonic oxide and carbonic acid) are always gases, while the oxides of silicon, iron, and manganese, can only, on account of the high temperature, appear in part in the form of vapor. That these last really appear in this shape is proven by the analysis of the brown smoke, giving silica, protoxide of manganese, and protoxide of iron.

Of the other bodies contained in pig-iron, only sulphur, phosphorus, and copper need be considered in practice. From the commencement of the process, sulphur gradually disappears as sulphurous acid, but a small part always remains pertinaciously in the iron. Phosphorus and copper remain in the iron unchanged. The first is indeed oxidized at the commencement, and passes into the slag as phosphoric acid, but at a higher temperature it is again reduced and passes back into the iron.

Other bodies appear only in very small quantities in pig-iron, and in practice are of no importance; but still, in so delicate a process as spectral analysis, they cannot be disregarded. To these belong nickel and cobalt, which, being more difficult of oxidation than iron, remain in the product in the metallic state; titanium, arsenic, and antimony, of which the first is oxidized, and the last two volatilized; aluminium, magnesium, calcium, potassium, sodium, and lithium, which partly pass into the slag, and partly pass off with the gases in the form of vapor.

To these are added the constituents of the fire-proof lining of the converter, essentially silicic acid and alumina; but, besides these, also manganese, iron, the earths and the alkalies in greater or smaller quantities; and, finally, the blast carries with it, besides nitrogen, which passes off unchanged, vapor of water, whose hydrogen is contained in the gases. It is not improbable that free oxygen sometimes issues out of the metallic bath, but this probably ceases to exist as such inside the vessel, chiefly in converting carbonic oxide into carbonic acid, provided the temperature be not, perhaps, too high.

Conclusions as to the Character of the Spectrum.—During the entire process, with the exception of the first and last period, glowing gases and vapors stream out of the converter. Among these, next to nitrogen, carbonic oxide is present in the greatest quantities. In these gases, all those bodies which give characteristic lines by the refraction of their rays through a prism, will show, on observation through a spectroscope, these lines simultaneously.

But besides these gases, a quantity of glowing solid or molten bodies (iron, slag, etc.) is almost always in the stream of gas. These must produce a continuous spectrum, but since they are mostly subordinate to the gas, the bright lines produced by this last will appear on a continuous spectrum, serving, to a certain extent, as a background. The brightness of the lines, diminished by this means, is still further decreased by the diffused sunlight, which, in the observations during the day time, also gets into the spectrum, and increases the brightness of the continuous spectrum.

The glowing gases cool quite rapidly at the edge of the flame. This is shown by the forked appearance of the edges during the second period. The rays of the glowing body in the interior consequently fall through a stratum of gas, which, being of the same composition as the former, must absorb its rays, so that, instead of bright lines, dark bands of absorption may appear in the spectrum. This will be the case more or less, according to the

thickness or density of the non-luminous stratum of gas. If this stratum is sufficiently powerful to entirely absorb the characteristic rays of the glowing gases, then between the dark bands of absorption we will have the non-absorbed rays of the continuous spectrum, and these might, in consequence of their apparent brightness, the result of contrast, be taken for real lines. If the stratum does not absorb sufficiently, then the real bright lines will appear but faintly. This last may be expected as most probable.

OBSERVATIONS OF THE BESSEMER SPECTRUM.

To aid in comprehending the following discussion, we have represented in Fig. 1 the continuous spectrum, produced by sunlight, or by any incandescent body. The most important lines of absorption, the so-called Frauenhoffer lines, are also represented, and marked with the usual letters. These last will be used without further additions to designate the position of definite lines. When lines lying close to each other give the impression of belonging together, be this due to their general appearance, or to their being separated by a space from other lines, they will be designated as groups of lines. Such groups often show a greater brightness on one side than on the other. This appearance is characterized by the term shaded. When "right" or "left" is mentioned, "right" always means towards the most refracted part of the spectrum, i. e., the violet; "left" means towards the least refracted part of the spectrum, i. e., towards the red.

General Characteristics of the Bessemer Spectrum.—At the commencement of the charge only a faint continuous spectrum is visible. It is only towards the end of the first period, simultaneously with the commencement of a decided flame, that characteristic bright lines begin to present themselves. At first the sodium line D appears alone; flashing up, and then disappearing for a moment, it soon remains steady with a brightness increasing with the development of the spectrum. It is visible during the entire process, is seen longer than any of the other lines, and sometimes does not disappear even at the end of the reaction. Soon after this line, other lines appear in the greenish yellow and green part of the spectrum. These lines are separated from each other by shaded bands, and are sometimes so faint, that one might feel inclined to take the bands for products of absorption, and the lines as the remains of the continuous spectrum. Gradually two lines can be distinctly recognized; then the shaded bands resolve themselves into other lines with spaces between them, and groups of lines are formed, one in the yellowish green, the other in the green. With the increasing brightness of the flame, and the continuance of the process, the groups of lines resolve themselves into a large number of lines with separating bands, at the same time the spectrum of the lines expands itself. Another group of lines appears in the bluish green, and a few lines can even be recognized in the bright blue. If the spectroscope be sufficiently strong, soon after the appearance of the sodium lines the characteristic lines of potassium and lithium may be noticed in the red, and in the violet a second line characteristic only for potassium. Simultaneously with the first bright lines in the yellowish green and green, a line may be observed in the violet near the potassium line β, but more strongly refracted than this last.

It is claimed that during the third period when the flame is most brilliant, still more lines are sometimes visible in the dark blue and bluish violet. An ordinarily good spectroscope does not show these lines, nor indeed some of the others; the sodium line, however, and the three groups in the yellowish green, the green, and the greenish blue, can still be recognized, even when the charge shows considerable smoke.

With the decreasing brilliancy of the flame in the last period, the characteristic lines of the spectrum disappear in the inverse order of their appearance, but in much shorter intervals. The disappearance of the groups of lines in the yellowish green and green (these made their appearance first) indicates that the process is ended, and on turning the converter down, the sodium line generally, though not always, disappears.

The flame which forms when the spiegeleisen is let in, generally shows with more or less distinctness the same spectrum as that observed in the second period of the process.

The Bessemer Spectrum according to Roscoe.—All we learn from Roscoe's report

concerning his observations of the Bessemer flame at Brown's Works in Sheffield, is that the characteristic lines appear in those places where lines due to carbon, iron, sodium, lithium, potassium, hydrogen and nitrogen, appear in the spectrum. In this case, therefore, we have no starting-point to aid us in forming an opinion.

According to Watt.—Roscoe's assistant, Dr. Watt, continued the observations, and gives the following description of the spectrum :

At the commencement, a continuous spectrum is visible. After 3 or 4 minutes the sodium line appears, at first flashing out and then disappearing, but soon steadily visible. Hereupon a very great number of bright lines and very dark bands appear, which increase in distinctness till the end of the process. At the termination of the process, on the other hand, all the dark bands and most of the bright lines disappear. The spectrum is characterized by the complete absence of all lines in the refracted parts, and extends hardly any further than Frauenhoffer's line *b* (in the green).

That this last-mentioned peculiarity, which Watt is inclined to consider characteristic, results only in the instrument used, is shown by the remarks further on.

It has, moreover, been mentioned above, that in the case of charges disposed to show a good deal of smoke, the more strongly refracted lines cannot be seen even with a good spectroscope.

The spectrum which is visible before the close of the oxidation process is represented in Fig. 4, according to an enlarged drawing by Watt. In connection with this, Watt remarked that the bright bands appear at the time of greatest development, as groups composed of numerous lines.

From the figure it will be seen that the sodium line is strongly developed. To the left of it there is another group of lines which do not extend quite up to *c*. Between D and F there are 5 shaded groups, 4 of which lie between D and *b*, with the brightest edge to the right, and the 5th between *b* and F, its brightest part being in the middle. To the right of F there is still a faint line in the blue. After letting in the spiegeleisen, the spectrum shown by the ordinary flame during the oxidation period some times reappears, according to Watt, but more generally the spectrum is apparently quite different. On close examination, however, it may be seen that, although the general appearance is quite different, yet the lines of the two spectra agree.

This spectrum of spiegeleisen is represented in Fig. 5. We notice the perfect coincidence of the group of lines to the left of D. On the other hand, we observe that the 5 other groups are much more clearly defined, so that it gives the impression that we here have a simpler spectrum, which becomes complex during the process by the addition of other lines.

According to Zielegg.—Zielegg made his observations, as has already been remarked, at the Bessemer works, in Gratz, where grey charcoal pig-iron was used. His exact and reliable investigations gave the following results :

At first only a faint continuous spectrum can be noticed. The yellow can scarcely be detected, the blue and violet are weak, and even the sodium line is lacking. Gradually the brightness increases, and with it the continuous spectrum becomes more distinct. With the first slag discharge, soon after, the sodium line flashes up, and after 1 or 2 minutes remains steadily visible. This is the commencement of the second period. At the same time the potassium lines α and β, in the red and violet, appear.

In the boiling period the sodium line becomes so bright that it surpasses in brilliancy those parts of the spectrum lying nearest to it. In the yellowish green, in the green and in the blue, lines appear which form groups of threes and fours, about equally distant from each other. Of the groups in the greenish yellow and green, only one line appears at first in each, the others then follow gradually.

At the end of this period, these groups of lines are quite distinctly visible, but they are most distinct in the third period, at which time the lines in the blue also show themselves. The bright part of the spectrum now appears, divided in four groups of equal size. One lies in the neighborhood of the sodium line in the yellow, and is bounded on the right by a bright yellow line. The second group is in the greenish yellow, and is characterized by three broad lines, of which the third (the one furthest to the right) is the brightest. In the third group there are four greenish blue lines, of which the one next to the

last is the brightest. The fourth group contains four blue lines of equal brightness. The intervals between the lines of the third and fourth groups appear dark and look like lines of absorption.

In the more strongly refracted parts of the spectrum, besides the potassium line β in the violet, another still more strongly refracted line may be recognized, which makes its appearance already at the commencement of the boiling period. During the time of most energetic reaction, in the last period, a sharply defined line in the blue violet is added, while in the less refracted part of the spectrum, to the left of the sodium line, in the orange red (about the place of calcium a) two or three lines are visible, lying closely together and not sharply defined.

The most completely developed spectrum, such as is only seen with a very perfect apparatus, and with charges showing little smoke, has been drawn by Zielegg with great accuracy, and since it has found general confirmation, it has been given in Fig. 2.

The order of the appearance of the various bright lines has been represented in the following table in such a manner, that those placed furthest to the left appear first, and those furthest to the right, last:

Scale of Fig. 2. Group Mark.	Slag Period. 1.	Slag Period. 2.	Boiling Period. 1.	Boiling Period. 2.	Boiling Period. 3.	Boiling Period. 4.	1.	2.	Mark of the Scale
30.4		Potassium α.							30.40
27.8		Lithium α							27.8
α {25.7, 25.5, 25.3}						Red lines sharply defined; 1st and 3d the plainest			25.7 25.5 25.3
24.9				Dark band not sharply defined					24.9
24.6	Sodium line								24.6
24.5				Narrow dark band					24.5
β {24.0, 23.5}					Yellowish green lines				24.0 23.5
22.9			Brightest line in β						22.9
γ {21.9, 21.75}					Light green lines				21.9 21.75
21.65			Brightest line in γ						21.65
21.2							Bright green lines		21.2
δ {20.7, 20.5, 20.3, 20.05}					Greenish blue lines				20.7 20.5 20.3 20.05
ε {19.3, 18.95, 18.6, 18.15}					Light blue lines				19.3 18.95 18 6 18.15
15.8						Group of blue lines stopping at 15.8.			15.8
ζ {12.6, 11.2}						Four blue lines			12 6 11.2
8.6								Bluish violet line	8.6
4.9		Potassium β							4.9
η 4.7			Bright violet line						4.7

Towards the end of the third period, the brightness of the groups of lines diminishes, and they disappear in the order of their appearance (consequently in the above table from left to right). Shortly before the completion of the charge, all the lines of the third and fourth are no longer visible, and the spectrum assumes the appearance it had at the commencement of the boiling period (1). The vanishing of the last of these lines marks the completion of the oxidation process.

Comparing Zielegg's spectrum with that of Watt, we find that the dark band to the

left of the sodium line at 24.9 of the former is wanting in the latter; that the group α extends in Watt's spectrum to 27.5, consequently further to the left than in Zielegg's spectrum, and shows furthermore a greater number of bright lines. The group β agrees in its extent, though not in its single lines. By Zielegg, group γ is narrower and more sharply defined than by Watt. Groups δ and ε agree in their main points. The blue group stopping at 15.8 is represented by Watt as being less developed, and all the lines lying to the right of it are entirely wanting. The light green line of Watt at 21.2 is not marked down by Zielegg, but is mentioned in the description. The single bluish green line of Watt at 19.6 is entirely wanting with Zielegg.

Later Observations.—All later observations in regard to the appearance of the spectrum, confirmed what Zielegg had established with such great care. From the "Maximilianshütte" in Bavaria, Blerchsteiner, and from Seraing, in Belgium, Habets, report similar observations. The observations at Neuberg and at the Königshütte also gave no contradictory result, although the hopes entertained of the usefulness of the spectroscope in judging of the process, was considerably toned down. This was in consequence of the slight development of the spectrum and of the disappearance of the characteristic lines before sufficient decarbonization, as soon as the charges smoked considerably. In point of fact, numerous observations made by Sattler and Hasenöhel, at "Königshütte," have shown that with cold charges and the production of soft steel, the disappearance of the lines in the green and greenish yellow coincide exactly with the time at which a skilful engineer, judging from the appearance of the flame, gave the order for turning the converter. On the other hand, they did not succeed in finding lines whose disappearance would mark the point of interrupting the process for the purpose of producing the harder qualities of steel, although this point could be determined with sufficient accuracy with the eye. With hot charges, showing a good deal of smoke, and with iron directly from the blast furnace, the disappearance of the lines occurred so soon that the interruption of the process, according to these signs, gave entirely wrong results; that is to say, a product which was not sufficiently decarbonized. At Neuberg, on the other hand, under similar circumstances, the product was burnt (*i. e.*, the decarbonization had proceeded too far), even though the engineer who had conducted the operations at Gratz, where the spectroscope had given such practically useful results, had assisted at Neuberg.

Finally an appearance must be mentioned, to which Kupelwieser has already called attention, and which the author has frequently had occasion to observe at Königshütte. It is the peculiarity, that the groups of lines lying in the yellowish green, the green, and the bluish green, do not disappear *gradually*, as Zielegg says, but vanish suddenly to reappear at the next moment, though fainter than before. This vanishing and reappearing continues, the lines growing fainter till they disappear entirely from the spectrum. This, of course, greatly hinders the correct determination of the point for ending the process. The same remark is true of the sodium line. It also disappears for a time and flashes up anew, just as it always does at the commencement.

The Spectroscope.—On account of the small field which contains the clearly visible and characteristic lines of the Bessemer spectrum, it is necessary that the spectrum should be considerably extended in length. The apparatus first employed at the Königshütte, did not answer, because, by the refraction of the rays through a single prism, the spectrum was too short, and the lines lay too close together to be distinguished from each other. Although, on account of the great brightness of the Bessemer flame, its spectrum may, without injury, be considerably lengthened by means of several refractions, it is nevertheless not advisable in practice to have too great a field of view, since it makes the observation more difficult and draws away the attention from the most important point.

A refraction of the rays through two prisms is to be recommended most for apparatus to be practically in Bessemer works. The apparatus in use at the "Königshütte" was made at the workshop of the Imp. Polytech. Inst., at Vienna, by Messrs. Starke and Kammerer. To protect the prisms against dust and dirt, they are enclosed in a wooden box furnished with a lid. From this box tubes protrude, one to receive the rays before refraction,

the other to bring the spectrum to the eye. The axes of these two tubes are at right angles to each other. During the observation the whole box is placed on a tripod, furnished with a ball and socket joint. The slit through which the rays of light pass into the tube may be increased or diminished by means of a thumb-screw and a spring. The rays are refracted by means of two flint-glass prisms whose sides are 1¼ in. long, and whose height is 1¼ in., and then passes into the telescope, which magnifies 6 times. Through this telescope, which can be regulated to suit the eye, the spectrum is observed. In order to be able to compare the Bessemer spectrum with that of other bodies, a small prism is placed before the slit of the tube for admitting the rays, and partially covering it. Thus, two spectra, situated one above the other, are obtained. When in use, the apparatus is mounted 20 to 30 ft. from the converter, and the tube with the slit is directed to the rim of the central cone of the flame.

Habets recommends an arrangement of the spectroscope made by Browning and Sorby in London, and successfully used at Seraing. In this instrument, the axes of the telescope and of the receiving tube are in the same vertical plane, an arrangement which enables the operator to make his observations with more ease when the instrument is to be held in the hand.

DEDUCTIONS FROM THE OBSERVATIONS.

Sodium, Potassium, and Lithium Lines.—There is no doubt that the bright lines heretofore ascribed to sodium, potassium, and lithium, really belong to these bodies. A direct comparison shows their perfect coincidence. These bodies may be partly derived from the iron, but beyond doubt they come chiefly from the fire-proof material with which the converter is lined. Already, during the warming of the converter, and even when the lining is entirely new, the flame produced by the burning of the charcoal or coke contained in the converter, shows them in its spectrum.

Iron Lines.—The iron spectrum, according to Thalèn, is represented in Fig. 6. On account of its numerous lines, many of which are found in the green (a part in the Bessemer spectrum also rich in lines), it is difficult to determine the coincidence of the two spectra, and if this exists, to determine how far it goes, since the characteristic iron lines in the blue and bluish violet do not harmonize with the few lines of the Bessemer spectrum in these parts.

Watt has called attention to the circumstance that the line situated at 21.2, between the third and fourth groups, and to the left of E, one of the lines of the group δ, situated between E and b, and a third line at 19.6 to the right of b, must belong to iron. Furthermore the bluish green lines of Zielegg, between 17 and 18, might also belong to iron. In point of fact it would be very surprising if no iron lines could at all be found. Numerous as the lines of iron are between E and b, they still agree so little in their general appearance with the most characteristic lines of the Bessemer spectrum, that it gives room to the supposition that the brightness and size of the lines of the Bessemer spectrum do not allow the iron lines to appear.

Watt compared the spectra produced by passing an electric spark between two iron poles in the air, and between two iron poles in hydrogen gas, with the spectrum of the Bessemer flame, and found only the three lines mentioned above to agree.

Lines due to Carbon and its Combinations.—It is natural to ascribe the characteristic lines of the spectrum to carbon, or its combinations. On the oxidation of carbon the entire success of the Bessemer process is based, and Zielegg, with reason, calls attention to the circumstance that so steady a spectrum as that visible from the beginning of the boiling period to the process, can hardly be ascribed to any other bodies than carbonic oxide or nitrogen, since no other body can be present in such great quantities in the Bessemer flame. Since nitrogen gave no spectrum, either on burning its combinations, or a body rich in nitrogen, he concludes that the lines must be ascribed to carbonic oxide gas. For this argument, Zielegg found another proof in the fact that the characteristic groups of lines of the Bessemer spectrum (although not so well developed) showed themselves in the carbonic oxide flame, produced during the warming of the retort with charcoal and coke.

Roscoe, Watt, and others, did not doubt the correctness of this explanation. Schlenz found its confirmation in the

fact that other flames, consisting principally of carbonic oxide, as, for instance, the tymp flame, the flame at the throat of a blast furnace, that of the furnace gas for heating the blast and boilers, that of the English finery fire, etc., gave spectra that coincided very nearly, or entirely, with the Bessemer spectrum. Kupelwieser thought he had proved it by an experiment on a small scale. On a small Leffstroem assaying furnace he placed a truncated cone line, with fire-proof material, and 3½ inches high, and compelled the gas to pass through a small opening, 1 to 1¼ in. in diameter. The spectrum of this flame is said to have given the groups α, β and γ of Zielegg. This last experiment would have had the greatest value as a proof if it had been made with a complete —not, as mentioned, with a very small apparatus, and had been supported by figures; for the eye alone, without the aid of a scale, is only too apt to lead astray in spectral analysis. Furthermore, this gas, just as the gas produced during the warming of the converter, is no pure carbonic oxide gas, but one that has come in contact with particles of clay and iron. Consequently we have no guarantee that it is free from particles due to these substances.

In spite of all these hypotheses in favor of the appearance of a carbonic oxide spectrum during the Bessemer operation, it was still remarkable that the burning of pure carbonic oxide gas in a stream of oxygen gave no characteristic spectrum. It is well known that in this case only a continuous spectrum was obtained, in which the green and blue parts were particularly developed. The comparison also which Watt made between the Bessemer spectrum and the spectrum of an electric spark in carbonic oxide, showed no resemblance between the two.

Brunner has, with reason, remarked that we cannot, with Zielegg, seek for the cause of this difference in the higher temperature of the Bessemer flame, for otherwise it would be necessary to assume that the burning of a mixture of pure carbonic oxide and oxygen produces a lower temperature, which is improbable. At any rate, this latter temperature must be higher than that produced during the warming of the converter, yet the flame then produced shows the characteristic lines.

Another remarkable fact, which, however, is only apparently against the assumption of a carbonic acid spectrum, is in the non-agreement of the Bessemer spectrum with other known spectra due to carbon. In regard to the shading of the groups of lines, we notice just the contrary. In the Bessemer spectrum the shading is from right to left; in other spectra due to carbon, from left to right; so that in the first case we have the brightest line to the right, that is refracted most, and in the others it is to the left, that is refracted least.

This difference was noticed by Watt in the examination of the spectrum produced by burning a mixture of olefiant gas and oxygen before the oxyhydrogen blow-pipe, and also by Zielegg himself in his comparisons with the spectra of carburetted hydrogen, of elalyl, and of cyanogen. From it Zielegg concluded that the spectrum of a carbonic oxide flame was a very peculiar one, and was to be regarded as a spectrum due to *glowing carbonic oxide*, and not to carbon. This inference must be mentioned here, for it cannot be contested in itself, and would give a sufficient explanation of the Bessemer spectrum, if this were, in fact, the result of carbonic oxide.

Lines of Manganese.—It was Brunner, in Neuberg, who first pointed out that the reasons above set forth were scarcely sufficient for attributing the characteristic lines to a carbonic oxide spectrum, but that they must be due to some other bodies contained in the pig-iron. "The very appearance of these lines in the spectrum of the flame, produced in warming a converter whose lining had already been used, as noticed by Zielegg, and their absence on warming a converter whose lining was entirely new, is a proof," Brunner concludes, "that they result, not from the carbonic oxide produced in both cases, but from the scales of metal remaining in the converter after having been used. Since the known iron lines did not suffice for an explanation, it was not far-fetched to think of the manganese spectrum, more especially since the violet line belonging to it seemed to coincide with the line η of Zielegg."

That manganese is really volatilized, and in part passes off in combination with silicic acid and protoxide of iron, has already been mentioned at the commence-

ment of this article. The assumption of Brunner was entirely justifiable in itself, and only needed proof, that is to say, a comparison. The first examinations of the manganese spectrum were made by Theo. Simmler. He describes the spectrum as follows: "We have 4 comparatively broad green lines crowded together, and only at a great distance, in the outer violet, another isolated, narrower, but bright line." It turns out that the first two lines lie in the light green, and the fourth in the bluish green part of the spectrum, and that the violet line is situated near the potassium line β, without coinciding with it. 0.012 milligr. of manganese still gives the first two lines quite distinctly.

Besides this, we have spectra of manganese by Huggins and by Robert Thalèn, and their most important lines are delineated in Figs. 7 and 8. Irrespective of the fact that the two spectra do not agree—for Huggins gives two principal groups between C and D, and Thalèn only one, while the violet line, lying close to the potassium line β, is not at all noticed by Huggins—like most of the complicated spectra represented by simple lines, they are not sufficiently characteristic for purposes of comparison.

Hasenöhel examined the manganese spectrum anew at the "Konigshütte," but because the spectroscope lacked a scale for measuring, only the supposition, not the certainty, that it agreed with the Bessemer spectrum could be announced. On this account further observations were made here (at Berlin), which gave the spectrum represented in Fig. 3. This was produced by heating chemically pure chloride of manganese, moistened with pure hydrochloric acid, before an oxyhydrogen flame issuing out of a glass stopcock. In order to fix the lines that appeared till their position could be read off on the momentarily illumined scale, it was necessary to determine the position of the substance (placed on a moistened platinum wire) by experiment. The agreement of the principal lines, especially of the bright bands in the characteristic group β, the coincidence of the shading from right to left which appears exactly as in the spiegeleisen of Watt, and the similarity of the entire appearance, show the identity of the larger part of the Bessemer spectrum with the spectrum of manganese. In observing the simple manganese spectrum, it has also been found that the number of lines into which the four groups resolve themselves, increase with the increase of temperature. The violet line agrees exactly with that of the Bessemer spectrum. Whether the lines in the reddish yellow, which agree better with the spectrum of Watt than with that of Zielegg, are due to indiscoverable traces of calcium (as Simmler has assumed), need not be discussed; but it is not probable, since both Huggins and Thalèn have marked down a group of lines in the same spot. Nevertheless, it would not be surprising if, on account of the calcium always contained in the fireproof lining, the Bessemer spectrum should show lines belonging to this body. The experiment of Lichtenfels, however, speaks against this assumption. On direct comparison of the Bessemer spectrum with the spectrum produced by burning chloride of calcium in an alcohol flame, he failed to find any coincidence in the lines. Comparing the lines of Zielegg's Bessemer spectrum with Thalèn's calcium spectrum, the bluish violet line 8.6 seems to agree sufficiently. It is possible that only at the high temperature which exists when this line appears, calcium vapors are formed, but that then, the characteristic lines of calcium α and β to the left and right of D, in the bright part of the spectrum, are suppressed by the brilliancy of D. The manganese spectrum becomes remarkably like the Bessemer spectrum, if the sodium and potassium lines are produced simultaneously, the platinum wire being at the same time made to glow slightly. The bright lines then lie on a faint, continuous spectrum. By causing the wire to glow more brightly, the continuous spectrum becomes so brilliant that the bright lines are no longer visible, though at the same time it is impossible to discover lines of absorption corresponding to these lines.

If, now, there could have been still any doubts that the Bessemer spectrum was, in its principal points, a spectrum of manganese combined with lines of iron, potassium, sodium, lithium, and perhaps calcium, these were entirely removed by a series of simultaneous comparisons of the manganese and Bessemer spectra in the same spectroscope, made by A. V.

Lichtenfels. Lichtenfels found not only a general agreement between the four characteristic groups of lines of the Bessemer spectrum with the four bands already noticed by Simmler, but also that the single component lines into which the groups resolved themselves, harmonized completely in the two spectra. Two of the groups he found very distinct; the other two situated towards the blue were fainter. The violet line could not be detected either in the Bessemer spectrum or in that of manganese with the apparatus used. In regard to this last, however, our own observations do not admit of a doubt as to their identity.

Bands of Absorption.—The bands lying between the principal groups of the Bessemer spectrum might be bands of absorption. In this case, however, in the manganese spectrum they would also be due to absorption. This might be possible, in consequence of the formation of glowing particles of manganese during the volatilization of the chloride of manganese in the oxyhydrogen or alcohol flame; but even in this case nothing would be changed as to the identity of the two spectra.

According to Watt, the dark band at C shows itself especially during damp weather, and since it agrees with the red band of hydrogen, he considers it a band of absorption.

That the sodium line can also appear as a line of absorption is only mentioned by Roscoe. The author has never found it to be the case. There is still less ground for the assumption of the same chemist, that other dark lines are absorption lines due to carbonic oxide, than that the bright lines are to be attributed to carbonic oxide gas.

The two dark bands lying at the side of the sodium line (at 24.9 and 24.5) impress one most as being bands of absorption. If this supposition is correct, it still remains to be proved to what bodies they belong. The spectra delineated by Kirchhoff, Thalèn, and Huggins, give no explanation on this point.

From what has been said above, it is probable that lines of absorption are only the exceptions. There is certainly no ground for inclining to the assumption suggested by Habets as not unfounded, that the bright lines of the Bessemer spectrum are the remains of a continuous spectrum appearing between lines of absorption. Were this the case, the lines of the alkalies would first of all be present as dark bands, and not as bright lines.

Origin and Disappearance of the Spectrum.—As long as the Bessemer spectrum was considered as a carbon or carbonic oxide spectrum, the explanation of the origin and disappearance of its characteristic lines was very easy. It is well known that the oxygen of the air oxidizes the carbon of the iron by the agency of protoxide of iron, which forms first, and is easily dissolved in a singulo-silicate slag of the protoxide of iron. To bring forth the carbon reaction, a slag must be first formed; that is, the silicon of the pig-iron must be mostly oxidized. Since this takes place in the period of slag formation, the deduction may be drawn, that during this time no carbon is contained in the flame. When the iron is entirely decarbonized, no carbon can be contained in the flame, and the lines must again disappear.

Brunner pointed out that the iron called in practice decarbonized, still contains no inconsiderable amount of carbon. According to four analyses which he has communicated, the percentage of carbon sank first from 3.930 to 2.465, then to 0.949 and finally to 0.087, before the addition of spiegeleisin. A quantity which, according to his opinion, would still produce a sensible reaction on account of the delicacy of the spectral apparatus, provided the brightness of the flame were sufficient.

Schlenz, on the other hand, starting with the assumption of a carbonic acid spectrum, thought the cause of the late appearance of the lines was to be found in the proportion between the carbonic oxide and the carbonic acid formed. He says: "In the first period but little carbon is burnt in comparison to the other bodies taking part in the operation, and this is probably not oxidized to CO, but directly to CO_2. For this, the circumstance that a large quantity of unburnt air passes through the metal bath and out at the mouth of the converter, would be more than convincing. In this case the lines characteristic for carbonic oxide cannot appear in the spectrum of the flame, or they are so faint that they cannot be noticed. On this same account changes can take place in the spectrum during the specific carbonic oxide period, according

to the measure in which carbonic oxide gas and carbonic acid are formed; but since now the formation of carbonic acid falls considerably below that of carbonic oxide gas, these changes cannot be noticed, at least not with the instruments employed up to this time.

"Turner's opinion, that only carbonic oxide is formed, may be correct for the use of charcoal pig-iron, whose period of emission of sparks is always short, but not for the conditions of "Königshütte," where only coke pig-iron is employed. The qualities of the coke pig-iron employed at "Königshütte," have always been distinguished from charcoal pig-iron in having a comparatively long spark period, during which the metal has time to become thoroughly warmer, so that on this account it gives a warm steel, and a smaller percentage of waste and of scales in the casting pan. But with this kind of iron a large quantity of undecomposed air doubtlessly passes through the metal bath at the commencement of the process; that is during the spark period. Of this fact one may easily convince himself by means of the sparks of iron. If we take such a position as to be able to see into the mouth of the converter, we notice that a large number of iron particles of the size of filberts are thrown from the surface of the metal to the upper parts of the sides of the converter, where they burn up slowly, and give rise to the sparks that form the well-known stream of sparks outside the converter. Since this oxidation, which can be observed with perfect distinctness, commences in the converter itself, and is continued outside of it in the stream of glowing gas, we are warranted, if not forced, to assume that it can no more be the external air which alone causes these sparks, than that the sparks could be formed in the converter, if this were only filled with decomposed air and other gases not containing free oxygen. Hence the sparks can only be originated by the blast, a part of which passes through the metal undecomposed. Now, if this takes place, it is admissible to suppose that a small quantity of carbon oxidized at the commencement of the process, is oxidized directly to carbonic acid. On this account no carbonic oxide lines, or very few, will be noticed in the spectrum of the flame at the commencement of the process.

Just as in the commencement it cannot be observed, and only develops itself slowly, in the same way towards the end of the process when only very little or no carbon is present to be oxidized, the carbonic oxide gas spectrum must become faint, and at last entirely disappear, or at least be darkened by the remaining lines of the spectrum of the simply luminous flame, or of the glowing mixture of gases.

With the determination that we have no carbonic oxide spectrum to discuss, all these explanations become unnecessary and not to the point, and there are only left the following modes of explanation:

1. The luminous power of the flame at the beginning and end of the process does not suffice to produce the spectrum. 2. At these periods we have no flame (*i. e.*, a luminous stream of gas), but only an illumined stream of gas. 3. The temperature at the beginning and end of the process, is not sufficiently high to volatilize the bodies producing the spectrum. 4. The absolute quantity of the bodies volatilized producing the spectrum is at this time too small.

As regards the luminous power of the flame, which Brunner takes as the explanation, this is certainly very small at the commencement of the process. At the end, however, in a great many cases, and perhaps in all, it remains pretty strong. It is true that the luminous power of the flame at this time diminishes, but it is decidedly always greater than at the commencement of the boiling period, and then the spectrum is already well developed. This may be readily proved by the photometer. Sometimes (as at Hörde) the flame has considerable brilliancy. Only when a very heavy smoke is developed, is the luminous power considerably diminished, and then the disappearance of the lines is sufficiently explained. In other cases the explanation does not suffice.

In the second section of this article it has already been pointed out that the stream of gas issuing in the first period cannot be regarded as a flame. The gases are not yet in a glowing state, and no combustible gas is present which could burn in the upper part of the converter, or at its mouth. So far the second explanation would meet the case. In the same manner at the end of the process only an illumined, not a luminous, stream of gas appears; but

though the lines of the alkalies (consequently those due to the lining of the converter) remain up to this point, yet the manganese lines disappear before this point is reached. The disappearance of the lines cannot, therefore, in general, be explained by the lack of a flame.

The luminous power of a flame does not depend on the temperature, but essentially on the composition of the gases. It is well known that the luminous power and the temperature are only related in a flame of the same gas. On this account ascribing the appearance and disappearance of the lines to the differences in temperature does not amount to the same as ascribing these circumstances to the varying luminous power of the flame. But also the temperature gives no sufficient explanation, for Schlenz has pointed out that the flame during the warming of the converter, and the tymp flame of the blast furnace, are decidedly not as hot, and yet give the same characteristic lines as the Bessemer flame, while, on the other hand, the flame of the English finery fire, though one of the hottest, shows these reactions less distinctly.

If, therefore, the gradual appearance of the lines at the commencement of the process may be explained by the lack of a flame, by inferior luminous power, and by the lower temperature, then the only explanation left to account for the disappearance of the lines (except in the case of a great deal of smoke) is the small absolute quantity towards the end of the process of the body to be volatilized.

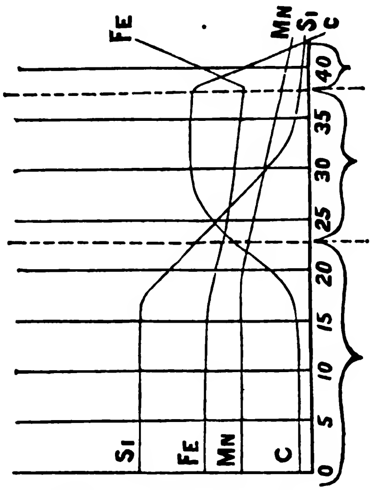
Evidently there can be no discussion as to the entire disappearance of the substances producing the spectrum. Iron is always present, as is also manganese, as shown in the analysis communicated by Brunner, giving, for instance, in decarbonized iron, 0.113 per cent. of manganese, and in the slag, 32.23 per cent. of protoxide of manganese.

Furthermore, it is known that spectral analysis requires a certain quantity of substance, varying greatly with different bodies. A trace of sodium will give its characteristic line, but, according to Simmler, a much larger quantity of manganese is needed to obtain a recognizable reaction, than that which can be detected by the well-known blow-pipe reaction with carbonate of soda. Consequently, spectral analysis does not depend solely on the *presence* of a body, but also on the presence of a certain quantity.

Schlenz probably first pointed this out in reference to the Bessemer spectrum. He says: "It would seem as if the absolute quantity of the body submitted to oxidation, had an essential influence on the appearance of the flame and on the lines of the spectrum. The division of the process into periods is motivated by the changes in or about the flame, observable with the naked eye, and due to the substances momentarily oxidized. For though it cannot be doubted—and every practitioner will have convinced himself of it by inspection—that from the commencement of the process to its entire completion, all possible chemical changes take place at the same time side by side; that from its commencement to its end, iron, carbon, silicon, manganese, etc., are constantly being oxidized, while the blast is constantly being decomposed; yet it can be just as little denied that according to the degree in which one or the other reaction excels in force, the flame must assume a different character. From this it can be deduced that the appearances in the spectroscope corresponding to these reactions in the converter, must show themselves simultaneously side by side, but that at different periods different appearances would principally be visible. According to the bodies concerned, the intensity of the oxidation, or the measure of the quantity oxidized in a unit of time, varies in the different periods of the process. This may, perhaps, be graphically represented by the following sketch.

This diagram says nothing more than what is daily observed: that at the commencement the oxidation of silicon is very energetic, while that of carbon remains in the background, while, at the same time, iron and manganese are pretty constantly oxidized. In the measure that the flame changes, that is, in proportion as the second period is introduced, the ratio between the quantity of silicon and carbon oxidized becomes inverse. At the same time the oxidation of iron and manganese is somewhat reduced. Finally, in the third period the oxidation of carbon nearly becomes a minimum on account of a lack in this body; that of manganese and silicon becomes less on this same account (the proportion of silicon being modified

by its greater or lesser degree of combustibility of this temperature which has now reached its maximum); and, finally, only the iron is oxidized, that body being present greatly in excess of the others.



PERIOD OF FORMATION OF SLAG.

Let us now examine in how far this opinion of Schlenz, according to which the absolute quantities of the different quantities volatilized are characteristic, for the spectrum can be applied to the experience that the Bessemer spectrum is mainly due to manganese.

Taking the analyses above cited to our aid, we find indeed that the manganese contained in the iron falls from 3.460 per cent. in the raw material to 1.645, 0.429 and finally to 0.113 per cent. in the decarbonized product; and that the protoxide of manganese in the slag first increases from 37.00 per cent. to 37.90 per cent. and then sinks to 32.23 per cent.; and furthermore that a certain quantity of manganese is to be found in the smoke. How much manganese is really lost by volatilization cannot be determined, since data are wanting as to the absolute quantities of slag and iron, consequently we cannot determine how much manganese has been lost by means of the eruptions.

But since the manganese contained in the pig-iron decreases constantly, and that contained in the slag after the termination of the boiling period also decreases, a considerable volatilization of this body is probable just at the time when the spectrum is best developed. Comparing with this the experiments that can be made in the laboratory, we arrive at the hypothesis, that the oxidized manganese which has entered into the slag is not volatilized, but retained by the slag; can therefore only get into the flame in the shape of solid or fluid combinations, and has consequently no influence on the spectrum. It was impossible to obtain a spectrum with the silicate of manganese and a flame of very high temperature, whereas volatilized metallic manganese (from chloride of manganese) readily produced it. If manganese could have any effect on the spectrum as an oxidized constituent of a silicate, then also the smoke containing protoxide of manganese, instead of darkening the spectrum, would call it forth more distinctly, or, assuming that it is greatly cooled at the edges of the flame, it would produce bands of absorption. If, on the other hand, our assumption is correct, then the characteristic lines will disappear towards the end of the process, as soon as only such small quantities of manganese are volatilized that no spectrum can be produced. This will take place whether the flame is hot or cold, is very luminous or the contrary, or ever so much protoxide of manganese be contained in the slag.

It may very well be possible that this appearance is intimately connected with the formation of carbonic oxide gas, and that on this very account the manganese spectrum gives such good results in judging of the state of the decarbonization under conditions generally favorable.

Manganese becomes volatile at comparatively low temperatures. It exists as a metallic vapor in an atmosphere of carbonic oxide gas; hence, during the warming of the converter, its scales (metallic crusts) give the manganese spectrum; for the same reason the tymp flame, in spite of its low temperature, gives a spectrum. Should there, however, not be a sufficient quantity of protecting carbonic oxide gas, as at the commencement and close of the Bessemer process (and to a certain extent in the lively oxidation of the English finery fire), then the manganese already volatilized will be oxidized, and will have no effect on the spectrum.

This hypothesis—for this explanation does not pretend to be more—would at the same time explain the usefulness of

the spectroscope in the Bessemer operation, under certain circumstances, and also the apparent contradiction between the intended process of decarbonization and the origin of the spectrum through manganese.

A second solution of this apparent contradiction might be found in the following: The percentage of manganese must always have fallen so low that it can produce no spectrum, in order to allow a sufficient decarbonization of the iron. It is known that the silicate of the protoxide of manganese is no solvent for protoxide of iron, and consequently the more it is present in contradistinction to the silicate of the protoxide of iron (an excellent solvent for the protoxide of iron), the more does it hinder or delay the decarbonization of the iron. On this property the most important characteristic of the manganiferous pig-iron used in the steel puddling process rests. Such assumption, however, agrees but little with the experience at Neuberg, where a burnt iron was obtained before the manganese lines had disappeared, and also contradicts the experiments cited above.

At any rate, the important influence of manganese on the decarbonization of pig-iron and on the formation of steel, is not to be mistaken. It plays an important part in all the steel processes, so that, not only for the Bessemer process, but also for Martin's and for still others, spiegeleisen has become indispensable, while at the same time other artificial additions containing oxide of manganese have generally proved ineffective. Hence, the collection of data with the spectroscope as to the role of manganese, is not only of theoretical but of practical importance. Metallurgists are therefore earnestly requested to continue investigations in this direction with the spectroscope.

LEAD IN THE CROTON WATER.—The attention of the Metropolitan Board of Health having been called to the frequent cases of chronic lead poisoning which occur in the city, the chemist to the Board, C. F. Chandler, was directed to investigate both the Croton water and the various hair tonics, washes, etc., with a view to discovering the probable cause.

Accordingly examinations were made of Croton water which had been in contact with lead for different lengths of time under usually occurring circumstances, of which the following are the results:

1. A gallon of Croton water from a lead-lined cistern, in which it had stood several weeks, was found to contain 0.06 grain of metallic lead.

2. A gallon of water which had remained six hours in the lead pipes of the chemist's residence, yielded 0.11 grain metallic lead, a considerable portion of which was visible to the eye, in the form of minute white spangles of the hydrated oxycarbonate ($PbO,HO + PbO,CO_2$).

3. Water drawn from one of the hydrants of the School of Mines laboratory, in the middle of the day, when the water was in constant motion, yielded traces of lead. This water reaches the school through about 100 to 150 ft. of lead pipe.

These results indicate the source of many hitherto unaccountable cases of lead poisoning, and are of a character to alarm the residents of New York, and to lead them to adopt precautionary measures for protection against this insidious cause of disease. Many have already introduced, as a substitute for lead pipe, the "tin-lined" or "lead-encased block tin" pipe.

Certainly no pains should be spared to impress upon servants the importance of allowing the water to run for a few minutes before taking it for drinking or cooking purposes, especially early in the morning after the water has stood all night in the pipes. The habit of filling the tea-kettle from the boiler, or of using water from the boiler for any purpose except washing, is very dangerous.

Experiment No. 2 explains a case which recently occurred in New York. An elderly gentleman was completely prostrated with paralysis or palsy. His physician at once suspected lead poisoning from his symptoms, and instituted inquiries which developed the fact that the patient had been using wheaten grits for dyspepsia, and that the first duty of the cook in the morning had been to soak them, preparatory to boiling them. She had therefore used daily the water which had stood all night in the pipes. The occurrence of a considerable portion of the lead in experiment No. 2, in suspension, instead of solution, is an additional argument for the use of filters, though it will of course be useless to employ them unless they are frequently reversed, that they may be cleansed.—*Chem. News.*

THE RESISTANCE OF VESSELS.

(*Continued from page* 394.)

It has been shown by Mr. Scott Russell,* that the condition of the broad and rounded parts of a ship, and of her hull between wind and water, is analogous to that of a raft; while the condition of the keel, the sharp part of the floor, and the grip and dead wood (or fine parts of the ends), is analogous to that of the board, floating edgewise, so that the ship is under the action of two conflicting sets of forces—gravity, centrifugal force, and pressure (constituting what may be called stiffness), tending to make her roll with the waves, like the raft—and the action of the water on the keel and sharp parts of the hull, which may be called *keel resistance*, tending to make her roll against the waves, like the board, and hence that she will take some kind of intermediate motion.

It has been pointed out, however, by Mr. Froude and Professor Rankine† that there is an essential distinction between the two sets of forces before mentioned, in consequence of which, though conflicting, they are not directly opposed; namely, that the stiffness is an active force, which tends not only to prevent the ship from deviating from a position upright to the effective wave surface, but to restore her to that position after she has left it, with a force increasing with the deviation; while the keel resistance is merely a passive force, opposing the deviation of the ship from the originally vertical columns of water, with a force depending, not on that deviation, but on the velocity of the relative motion of the ship and the particles of water, and not tending to restore the ship to any definite position. Hence those two kinds of force cannot directly counteract, but only modify one another.

For the mathematical investigation of the action of those forces, reference must be made to the original papers in the "Transactions of the Institution of Naval Architects." The following are the general conclusions:

The permanent rolling of a ship of very great stability, and without any sensible keel-resistance, is governed by the motion of the effective wave-surface, so that she rolls *with the waves*, or like a raft.

When the period of unresisting rolling of the vessel is to the wave period as $\sqrt{2}:1$, the permanent rolling is wholly governed by the motion of the originally vertical columns of water, so that she rolls *against the waves*, like a board of no stability floating edgewise.

In both of the preceding cases the vessel is upright when the trough or crest of a wave passes her, and her angle of heel is equal to the steepest slope of the effective wave-surface.

When the period of unresisted rolling of the vessel is less than the above value, her upright positions occur *before* the arrival of the troughs and crests of the waves, and her angle of heel is *greater* than the steepest slope of the effective wave-surface.

The greatest angle of heel in permanent rolling occurs when the period of unresisted rolling of the ship is *equal to that of the waves*, and it exceeds the slope of the waves in a proportion which is the greater the less the keel resistance, and becomes infinite when the keel resistance vanishes. Thus, isochronism with the waves is the worst quality that a ship can have as regards steadiness and safety.

When the period of unresisted rolling of the vessel exceeds that of the waves in a greater ratio than that of $\sqrt{2}:1$, her upright positions occur *after* the arrival of the troughs and crests of the waves, and her angle of heel is less than the steepest slope of the waves.

The forced or passive oscillations of ships are those which produce the most severe strains, because of their continual recurrence; the free oscillations being gradually extinguished by the resistance of the water. It appears, however, that the periodic time of the free oscillations has an important influence on the extent of the forced oscillations, especially in rolling; the most unfavorable proportions for the periodic time of free rolling to that of passive rolling being those which lie near equality, and between equality and $\sqrt{2}:1$. For the quality of these

* "Tansactions of the Institution of Naval Architects," for 1863.

† "Transactions of the Institution of Naval Architects," for 1863-4.

periods tends to produce an excess of rolling to which it would be difficult to fix a limit; and the ratio of $\sqrt{2}:1$, and those near it, makes the ship roll against the waves, thus throwing her into positions in which there is a risk of the wave-crests breaking into her.

A period of free rolling much less than that of passive rolling gives great stiffness, and makes the ship accompany the motions of the effective wave-surface. A period of free rolling exceeding $\sqrt{2}$ times that of passive rolling is favorable to steadiness, provided that this lengthened period be produced by the inertia of the ship, and not by insufficient statical stability.

The action of the water on a deep keel, on a sharp floor, or on fine ends below water, tends to moderate the extent of rolling produced by coincidence, whether exact or approximate, of the periods of free and passive rolling; but at the same time it lessens the effect of a long period of free rolling in producing the same result.

A deep draught of water is favorable, on the whole, to steadiness, but not to stiffness.

Should the centre of gravity rise and fall relatively to the water in rolling, and the periodic time of the dipping motion so generated happen to be either exactly or nearly one-half of that of the passive rolling, the result will be uneasy motion.

The steady pressure of the wind on the sails promotes steadiness, at a certain angle of heel depending on the moment of that pressure; the sudden gusts of the wind produce lurching.

As to *pitching, scending, and yawing*, it is chiefly important that, for the sake of dryness and safety, those oscillations should be performed in a lively manner among waves; and that object is best promoted by keeping the longitudinal radius of gyration short, as compared with the length of the ship; that is, by taking care not to place heavy weights in her ends.

The true principles of a ship's rolling among waves and their leading consequences were first set forth by Mr. Froude, in a series of papers in the "Transactions of the Institution of Naval Architects," in 1861, '62, and '63. Mr. Froude appears to have been the first to state the proposition that the tendency of the ship to roll among waves is primarily due to her tendency to keep upright to the effective wave-surface, and that the force which induces this tendency is, very approximately, the same as her *stiffness*, or resistance to heeling in still water. The disposition of a ship to follow the average motion of the portion of the wave which she displaces is, however, controlled (as has been pointed out by Mr. Crossland) by the circumstances that the wave water is continually undergoing a deformation of which the ship's hull is not susceptible. Mr. Froude has also shown* that if two plates be hinged together, so that, when in still water, they would float at an inclination of 45 deg. to the vertical, and if the hinge be parallel to the wave-crest, the effect of the wave-motion is simply to open or close the angle between them, and not to alter (sensibly) the horizontal and vertical lines which bisect the angle externally and internally.

As there is nothing to show that the rigidity of the angle between the plates would tend to make any marked alteration in the invariability of direction of the bisectors, the theoretical establishment of this fact is of great importance. Its meaning is, that the effect of bilge-keels is to increase the time, and, in a greater degree still, to diminish the amplitude of the oscillation, and that the use of bilge-keels is the direct mode of effecting this object.

That the problem of safe rolling is not quite the same with that of easy rolling. A roll towards the wave crest is well known as one of the most dangerous things that can happen to a ship in a high-crested sea-way, for the whole crest of the wave may then break in-board. Even when the ship follows the oscillations of the vertical lines, the wave-particles come flat on the ship's bulwarks and side. If she floats quite vertically she is still in the position of a cliff resisting a wave of the same period, whose height is the difference of heights of the surface wave and of the mean effective wave acting upon her.

As regards the impact of a wave, the most violent blow that a wave can give is against a surface parallel to the in-flexional tangent and to the wave-crest, and at a level with the line of inflexion. The

* "Transactions of the Institute of Naval Architects," vol. vi., for 1865, p. 181.

motion of the particles is then normal to the wave-surface. This remark, of course, does not apply to shore waves.

Throughout the discussion of the ship's oscillation among waves, it has been tacitly assumed that the wave-period itself might be regarded as constant. This is very far from either representing the facts, or the practical problem of the ship builder. The wave which the vessel has to encounter may be anything, from the 11 seconds wave, 600 ft. long, to a mere ripple. Practically, a vessel will not roll to waves whose length is much less than her breadth, nor will she pitch much among short waves. But, dismissing these from consideration, it may still be impossible to avoid some contingency in which a ship's period of free rolling may be equal to the wave-period. Obviously, the remedy in this case is for her commander not to keep her *broadside-on*. As a rule, no commander ever would do so in a dangerous sea-way; and even where comfort only is concerned, it is usually open to him either to shorten the effective—that is to say, the *apparent* wave-period—by putting her head a little to the swell, or to lengthen the apparent wave-period by putting her head a little off. He *must* do one of these things if he meets with actual and exact synchronism in anything like heavy weather.

As a practical matter, Professor Rankine remarks: "It would appear that a very close approximation to the form and proportions which are most favorable to steadiness, has, in some cases, been realized by practical trials alone; and that independently of the steadying action of sails; for there are vessels which, when under steam alone, in any moderate swell, keep their decks very nearly parallel to the horizon. It is of great importance that the lines and dimensions, and distribution of the weights of ships, which have been found by experience to possess this excellent quality, should be carefully recorded for the information of naval architects.

"On the other hand, there are vessels (especially screw steamers) whose ordinary extent of rolling each way is from 3 to 4 times the slope of the waves."

On the subject of Waves, we refer to the following papers and treatises:

Weber—"Wellenlehre."

Airy—"On Tides and Waves." "Encycl. Metropolitana" (reprinted in a separate form).

Scott Russell—"Report to British Association," for 1844. Also, "Modern Naval Architecture."

Stokes — "Cambridge Transactions," 1842 and 1850.

Earnshaw—"Cambridge Transactions," 1845.

Froude—"Transactions of the Institution of Naval Architects," 1862, and (incidentally) in his papers "On Rolling." Also, "Remarks on the Differential Wave in a Stratifield Fluid," "Transactions of the Institution of Naval Architects," vol. iv., for 1863, p. 216.

Rankine — "Philosophical Transactions" for 1863; "Philosophical Magazine," November, 1864; "Proceedings of the Royal Society," 1868; also, "Shipbuilding: Theoretical and Practical."

Cialdi—"Sul Moto ondoso del Mare."

Caligny—Papers in "Liouville's Journal," 1866.

T. Stephenson—"On Harbors."

With regard to the rolling of ships in wave-water, we believe that almost the only exact investigations are to be found in the "Transactions of the Institution of Naval Architects," some of which have been reproduced in "Shipbuilding: Theoretical and Practical," and reprinted in "The Engineer," and in "Engineering." They are as follows:

Froude—"On the Rolling of Ships," vol. ii., for 1864, p. 180, with Appendices, pp. 45 and 48.

Woolley—"On the Rolling of Ships," vol. iii., for 1864, p. 1.

Crossland—"On Mr. Froude's Theory of Rolling," vol. iii., p. 7.

Rankine—On the same, vol. iii., p. 22. "On the Comparative Straining Action of different Kinds of Vertical Oscillation upon a Ship," vol. iv,, for 1863, p. 203.

Scott Russell—"On the Rolling of Ships," vol. iv., p. 219.

Froude—"Remarks on Mr. Scott Russell's Paper," vol. iv., p. 232.

Scott Russell—Rejoinder, vol. iv., p. 276.

Woolley—Memorandum on same subject, vol. iv., p. 284.

Rankine—"On the Action of Waves upon a Ship's Keel," vol. v., for 1864, p. 20. "On the Uneasy Rolling of Ships," vol. v., p. 38.

Lamport—"On the Problem of a Ship's Form," vol. vi., for 1865, p. 101.

Froude—"On the Practical Limits of the Rolling of a Ship in a Sea-way," vol. vi., p. 175.

Reed—"On the Stability of Monitors under Canvas," vol. ix., for 1868, p. 198.

An abstract of the leading principles will be found as already stated in "Shipbuilding: Theoretical and Practical," edited by Mr. Rankine.

Some valuable practical observations on the rolling of ships in waves will also be found in a pamphlet, "Du Roulis," by Captain Mottez, of the French Imperial Navy.

MEASUREMENT OF WAVES AT SEA.

This is a thing which has seldom been done with any degree of accuracy. Not only is the vessel moving, but the apparent direction of gravity is not the true one. The result is, that the difference of direction between the tangents to two waves from a point a little behind the spectator is generally taken for the apparent angular height. This may evidently be far in excess of the true apparent height.*

Admiral Paris has invented a self-recording instrument for the purpose of measuring both the height and form of waves. A description of this will be found in the "Transactions of the Institution of Naval Architects," vol. viii., 1867, p. 279. It is unfortunately a differential instrument, without any means of getting a good datum line. It appears to be much better adapted for getting approximate profiles of complex waves than for obtaining accurate measurements of simple ones.

Observations on the lengths of waves present much less difficulty; a float sunk so as not to catch the wind (such as a bottle), and observed from a considerable height, will give the periodic time with a fair degree of accuracy, and the length may be inferred from the period.

General observations upon waves† are not in point. The object in the present case is to ascertain what the particular waves are in which the ship's rolling is being observed.

* See Mr. Rankine's remarks in the "Transactions of the Institution of Naval Architects," vol. iii., p. 27.

† Although very desirable for other reasons.

MEASUREMENT OF ROLLING.

It is very well known that a pendulum at sea does not give a vertical line, but a direction due to the joint effect of gravity, of its own free oscillation, and of the forced oscillation due to the motion of its point of suspension. A suspended clinometer is thus perfectly useless for this purpose. Barometers, cuddy lamps, and chandeliers generally oscillate through larger angles than the ship.

Mr. Froude ("Transactions of the Institution of Naval Architects" for 1862, p. 41) suggests watching the ratlins of the rigging come down to the horizon as a ready and fairly correct way of measuring the roll. The motion of the mast heads relatively to the stars, may be used in the same way.

M. Normand, Jr., of Havre, has invented a very ingenious clinometer suspended on gimbals, like a chronometer, in such a way as to be as little as possible influenced by the ship's motion.* We do not consider that any instrument depending upon gravitation is to be relied upon at sea, and we have been informed that M. Normand himself is not quite satisfied with his instrument.

Apart from observations depending upon the stars, or actual sea horizon, the only instrument that can be relied upon as giving an invariable plane is of the gyroscope class. A modification of Foucault's gyroscope was tried in the North Sea in 1859, by Professor C. Piazzi Smyth, who gave an account of the instrument and of its performance in the "Transactions of the Institution of Naval Architects" for 1863, p. 118.

An instrument upon the same rotatory principle, but self-recording, has been invented by Admiral Paris, Hydrographer of the French Imperial Navy. It consists of a spinning top, with its point of support above its centre of gravity. It spins in an agate cup, and the top of the spindle carries a camel's hair pencil, which marks a paper band, driven by clockwork, and passing through bent guides so as to keep close to the pencil. It is described, and some of its curves copied, in the "Transactions of the Institution of Naval Architects," vol. viii., for 1867.

What these instruments really give, is

* See "Transactions of the Institution of Naval Architects" for 1866, p. 187.

the deviation from an undetermined direction. They therefore give the time of rolling or pitching, and of any intermediate oscillation of a periodic character, and the amplitude of deviation from the mean line; but they evidently would not disclose any steady inclination to which the rolling might be superadded.

The gyroscope or top will, of course, have its own proper oscillatory revolution, which, however, soon spins out, on the same principle that a pegtop "sleeps."

On the whole, there does not seem to be much room for improvement in Admiral Paris's instrument, unless, perhaps, in diminishing the atmospheric resistance. Possibly, also, provision might be made for adjusting the point of support to the centre of gravity.

RECOMMENDATION OF EXPERIMENTS ON ROLLING.

The mathematical theory of rolling is very far from easy, and leads to equations of which there is no known solution. The time of a common pendulum, for instance, depends upon an elliptic integral, and, beyond the degree of complexity involved in such a junction, mathematics are in the condition of uncleared ground. Accordingly, while it is possible to give a rational account of the immediate gross results of a compound oscillation, these results cannot be expressed or measured with the requisite combination of generality and accuracy. In order to treat them we are obliged to introduce simplifying suppositions, which do not necessarily belong to our problem—as, for instance, isochronism—or, the neglect of certain elements of resistance, or the grouping of others.

Now, when this occurs with any branch of practical knowledge, the proper mode of applying mathematical investigation is to start, not from the known principles of general mechanics, but from an advanced base of observations peculiar to the science itself. In hydrodynamics, between minuteness and number, the ultimate molecular unit escapes our notice, and we are only able to observe effects in the gross; being thereby driven to a certain want of detail, both of observation and of reasoning, which allows us to trust our conclusions only when they have been made to rest on a broad experimental foundation. Whether we regard the theory of the propulsion of ships, or that of their rolling, our analysis has assuredly been pushed quite to the extreme verge to which general reasoning can be trusted; and a largely increased extent of exact observation ought to precede further attempts at inductive reasoning on these subjects. We have many exact experiments on propulsion, although from the complicated character of the phenomena involved, it is difficult to separate the issues; and this will probably not be set right without further special investigation. With regard to rolling, however, we have much vague observation, and but little exact knowledge derived from experiment.

We are not aware of any one published experiment on the rolling of ships in waves, in which the details necessary to make any mathematical use of the results are supplied. The data required are, as a minimum for each case:

1. A draught of the ship and her calculated elements.
2. The position of her centre of gravity.
3. Her periodic time in still water.
4. The condition of her wet surface.
5. The extent and period of her roll.
6. Was the rolling simple, or mixed with pitching?
7. The height, length, and period of the waves in which she was rolling.
8. Were these waves simple?
9. What alterations have been made in her displacement, her trim, and the position of her weights, as regards both centre of gravity and moment of inertia previously to the trial?
10. Force and direction of wind, and condition of ship as regards resistance to it.
11. Full details as to the manner in which, and the instruments or calculations by which, these data have been ascertained.

There is no doubt that for a comprehensive view of the subject, it would be necessary that these things should be ascertained with care for a large number of ships of various classes, and under very varied conditions. But this is too much to expect to get done, although we think it would be a good thing for the Government and other large shipowners to keep in view as an ultimate object. Meanwhile, we think it would be a very great experimental aid to science, if these things could be accurately settled for even two or three

ships, under different circumstances of weather, and different arrangements of weight, both in amount and distribution.

Similar experiments should also be made with reference to pitching.

The trials should be made with sails furled, and as little disturbance from headway as possible. We have every wish to have parallel experiments, tried under any possible conditions of sail and propulsion; and if it may be done, on the same ships, consecutively with the simpler experiments. But it will be seen that the data are already sufficiently complex at the best, and that they must be used clear of headway and leeway before they can be discussed with reference to these.

No experiments are of use for the purpose of inductive reasoning, in which any one of the data mentioned above is wanting.

We think the Government might fairly be asked to institute such a set of calculations and experiments. We cannot find that the exact information which we have suggested is in existence anywhere. We are certain that it has not been published in any available form; and we have reason to believe that the knowledge is quite as much needed and desired by the gentlemen responsible for the construction of the navy, as by merchant builders, or by students of theory.

We therefore recommend that the deputation previously mentioned with reference to the experiments on resistance, be also instructed to urge upon the Admiralty the importance, both practical and theoretical, of instituting such a set of experiments, of providing suitable instruments for recording exact observations, and of publishing the results. We also recommend the appointment by the Council of the Association, of a committee of *three* members, to confer with the officers of the Admiralty as to the drawing up of detailed instructions for conducting these experiments; and that the Lords of the Admiralty, in the event of their assenting to the proposals, be requested to nominate a committee named by the Association.

In conclusion, we beg leave to recommend that this report be officially communicated to the Councils of the Institution of Civil Engineers, the Institution of Civil Engineers, and the Institution of Engineers in Scotland, and the coöperation of those bodies sought, both in applying to the Government, and in making known among shipbuilders and other persons connected with naval architecture, as well what is the state of our existing knowledge, as what are the immediate desiderata for its extension.

An Earthquake-Proof Church. — The people of California, since the earthquakes of 1869, have a great deal of recurring shocks, and, as an indication of this wholesome fear and a desire to prevent loss of life, we have intelligence from San Francisco that the Roman Catholics are building there an "earthquake-proof church." This edifice–St. Patrick's Church —is built on a plan to prevent loss of life in the event of the shaking down of the walls. The side walls above the basement are only 30 ft. high. At this height, a roof rises, which, with the main roof, is supported independently of the walls by two rows of pillars inside of them. Both roofs are firmly bound to the pillars, and the pillars are fastened together by iron cross-beams, secured with heavy iron bolts, forming a network of great strength. The theory of the plan of construction is, that should the pillars be shaken down, the roof would be launched off outside the walls, instead of falling inside, thus giving a chance of escape from the ruins. In thus falling the roof would be carried aside a distance of 80 ft., the length of the pillars.—*Scientific Journal.*

The Mouth of the Mississippi.—The report submitted by the Engineer Department, on the work of deepening the passes from the Mississippi to the Gulf of Mexico, shows that Pass a l'Outre, the one selected for improvement, has been deepened from 11 to 17 ft., the channel being 175 ft. wide. The current, however, will soon reduce it to its former condition if the labor upon it is relaxed. The digging is done by a dredge-boat, constructed especially for the purpose, at a cost of about $300,000. In order to keep open two channels, the building of two more dredges is recommended, after which the annual cost of keeping the channels open would be about $200,000.—*The Engineering and Mining Journal.*

THE KING'S COLLEGE GIRDERS.

From "Engineering."

If any justification of this recurrence to the somewhat stale subject of the failure of the cast-iron girders crossing to the King's College dining hall is considered necessary, it will be found in the universally accepted engineer's axiom, that failure is more instructive than success. The lesson afforded by a failure, however, is entirely lost if a false deduction is allowed to pass current; and for that reason we consider it advisable to recapitulate some of the conclusions advanced in our pages immediately after the fall of the girders under consideration.

Our American cousins discuss the engineering questions arising in their fatherland on this side of the globe, with as lively a degree of personal interest as English engineers themselves. For their facts they are necessarily dependent upon our technical journals, and this condition should afford an additional incentive to exactness and thoughtfulness on the part of the framers of reports in those journals. Had this responsibility been properly appreciated by all of our architectural and engineering authorities, our Transatlantic contemporary, the "Scientific American," would not have perpetrated the anomaly of making the failure of a rotten cast-iron girder at King's College, the text of a leading article entitled, "Pumping Down Buildings."

It may, perhaps, be possible to "pump down" buildings founded upon certain special and treacherous geological formations; but it is certainly a catastrophe which has never befallen the dwellers in the valley of old Father Thames. Underground railways have tapped the gravel overlaying the London clay, in every direction, and for many miles. The trenches for these railways constituted in effect so many huge wells, the bottoms of which were sunk some 15 ft. to 20 ft. below the level at which the water stands in the surrounding gravel basin. To keep these trenches dry during the construction of the works, it was necessary to sink sumphs some 10 ft. deeper still, and from each of these numerous sumphs vast volumes of water, clear as from any spring, were ejected day and night by powerful pumps. All this has been done through the most thickly built city in the world, where ponderous and lofty buildings, in many instances old and shaky, extend to within 5 ft. of the edge of the trench, and in no single instance has any building been "pumped down," although some 20 ft. of the sand and gravel immediately under the foundations have been completely cleared of water.

We do hope, therefore, that we have heard the last of the King's College girders being "pumped down." Had there been any difficulty in making a correct diagnosis of the case, such an error would perhaps have been venial; but under the actual circumstances it is inexcusable. The true cause of the accident was clearly demonstrated in our first article on the subject ("Engineering," vol. viii., p. 393), which was written after a careful inspection of the broken girders. As some recent tests of the girders have exactly corroborated the deductions then made, we may usefully recapitulate our summing-up, which was as follows:

"The simple facts of the case are that the girders were carrying two-thirds of their calculated breaking weight, and probably would be carrying the same at the present time, had not the presence of some extensive flaws in one of the girders at a point 3 ft. from the support induced failure at that relatively little strained portion of the girder. The fall of one girder was of course followed by the destruction of the whole. We leave our architectural and building friends to draw their own conclusions."

We will now see if any additional light has been thrown upon the question by the results of the testing of one of the King's College girders, of slightly different dimensions to the original broken girder considered in our article. The calculated strength of the girder as there given, reduced to the equivalent breaking weight applied at the centre, is 32.2 tons at the span of 19 ft. Now the girder actually tested was 20 in. deep, whilst the one which first failed was but 18 in. If the girders were in other respects similar, this increase of $\frac{1}{9}$th in the depth would augment the transverse strength of the girder by the slightly increased fraction $\frac{1}{8}$th. But

the thickness of the bottom flange was $1\frac{3}{4}$ in. instead of $1\frac{5}{8}$ in.; consequently there would be due to the second girder a further increase of $\frac{1}{13}$th in the resistance. Again, the latter girder was tested at a span of 18 ft., whilst the actual span of the original girder was 19 ft., and the corresponding breaking weight at the centre would, of course, be greater in the inverse ratio of the span, which gives us another increment of $\frac{1}{18}$th. The calculated breaking weight at the centre of the girder actually tested, assuming the quality of metal to be the same as that taken in the instance of the girder referred to in our first article, would be greater, by the sum of the several fractions enumerated, or $\frac{48}{187}$ths. Now, $\frac{48}{187}$ths of 32.2 tons, the calculated breaking weight of the girder which caused the catastrophe at King's College, is equal to 8.3 tons; consequently, the ultimate load which the girder actually tested might have been expected to sustain would be 40.5 tons. As the girder failed under a stress of 40.9 tons, no demonstration is required to convince any one that the result of this recent experiment does not afford any information which was not confidently advanced by us in our article of the 10th of December last.

The fact that the girders over the dining-hall had, for the last thirty years, been subjected to a constant stress amounting to $\frac{2}{3}$ds of the breaking load, must now be considered as both theoretically and practically demonstrated. It will, therefore, be unnecessary again to open the question; and it only remains for us to congratulate the College authorities upon the opportuneness of the moment at which the accident occurred, and to express our earnest hope that we have heard the last of "pumping down buildings."

A NEW WATER METER.

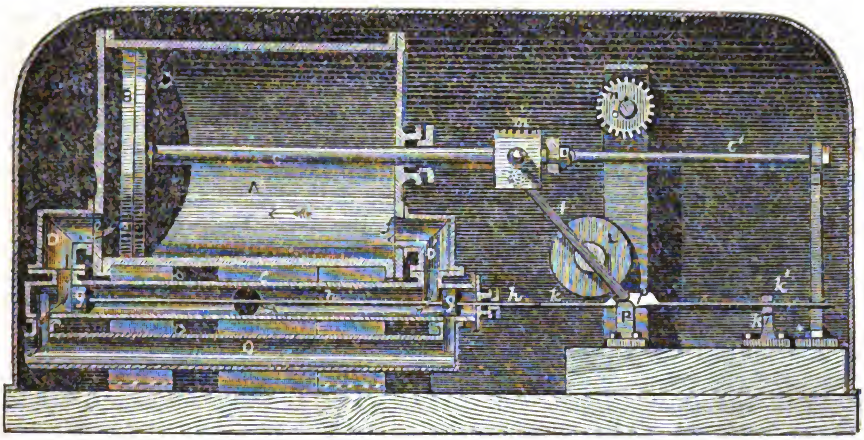
From "The Practical Mechanic's Journal."

This invention relates to a peculiar construction, arrangement, and combination of apparatus for measuring liquids and for registering the quantity measured, and consists in combining one or more horizontal cylinders of any known capacity provided with pistons and rods working through stuffing boxes with self-acting inlet and outlet valves and self-acting slide valve for directing the flow of the water to each end of the measuring cylinder or cylinders alternately. According to one arrangement the patentee fixes to the outer ends of the measuring cylinders a cylindrical valve case, having two lateral openings communicating through the end of the measuring cylinder with the interior thereof. In each of these valve cases work two piston valves, so disposed that, when one of the openings, say the inlet, is open to the cylinder, the other or outlet shall be closed, and *vice versa*. The spindles of these piston valves may be connected together by an oscillating beam or lever, which causes one pair of piston valves to descend when the other is ascending, the pressure of the water in the inlet pipe leading to the cylindrical valve cases alone serving to work the valves. In order to direct the flow of water into the opposite ends of the measuring cylinder or cylinders alternately, he adapts a suitable valve or valves to the inlet pipe or pipes, which valves he works by the aid of a weighted lever acted upon by a movable or fixed arm or projection at each stroke, so as to cause the weighted lever by its impulse to change suddenly the position of the slide or other valve or valves. The counting or registering mechanism may be worked by a pinion gearing into rack-teeth formed on the measuring piston-rod, or by any other suitable mechanical contrivance for transmitting motion from such rod. The whole is enclosed in a suitable framework or casing.

The engraving represents a longitudinal section of an arrangement wherein a single measuring cylinder only is employed in lieu of two, as in the first described arrangement. A is the measuring cylinder, B the piston working therein, and C the piston-rod provided with a cross head which slides along the guide rods C'. This rod C carries a rack *m* for actuating the counting mechanism through the pinion *n* on the spindle *o*.

This rod also carries a pendulous weighted lever I, having a bob weight L on its lower extremity, which actuates the

inlet valves in the manner hereinbefore explained; *e* and *f* are apertures made, one in each end of the measuring cylinder A, such apertures communicating respectively with the branch pipes D D′, which communicate with the opposite ends respectively of the inlet pipe G. Other openings in this inlet pipe communicate with the outlet pipe O, and all these openings are alternately opened and closed as required, by the piston-valves *g g′* carried by the one-valve spindle *h*. To the outer end of this valve spindle there is attached a slotted frame *k*, guided in its longitudinal movement by the fixed guide *k′*; P is a fixed projection over which the lower end of the weighted lever I is drawn at each stroke of the piston B. In order to prevent the end of the lever I from leaving the slot in the piece K when elevated, by passing over the projection P, the slides of the slotted piece are raised slightly, as at *p*. The engraving represents the water as entering the cylinder A



from the inlet pipe G by the inlet aperture *f*, the valve *g′* being in such a position as to close the communication at that end with the outlet pipe O, whilst at the same time the water is being expelled from the opposite end of the cylinder through the aperture *e*, into the outlet pipe *o*, the valve *g* being in such a position as to bring the outlet pipe into direct communication with the interior of the measuring cylinder just before the piston completes its stroke in either direction; the tail of the weighted lever I slips off the projection P, and the weight L causes the lever to strike against one end or the other of the slotted piece *k*, thereby suddenly reversing the positions of the two valves *g g′*; when the operations above described are repeated, and the water is admitted to the reverse end of the measuring cylinder and soon, each alternate stroke being duly counted by the counting mechanism.

BRUSSELS is advocated by the merchants of Berlin as a favorable place for an annual international exhibition.

IN the manufacture of quicksilver bottles, a circular disc of wrought-iron is, by a stamping process, gradually brought into the shape of a cylinder, open at one end like a glass tumbler. It is then put upon the end of a steel pin or mandrel, and by mechanical pressure is pushed through a hole, which hole is smaller than its own dimension, thereby reducing its exterior diameter, and at the same time drawing, or rather pushing, the iron over the mandrel in the same manner as a piece of dough could be drawn over the finger to fit like a glove. This process is repeated through a succession of smaller and smaller holes, one after the other, until at length it becomes a long cylinder. The neck of the bottle is formed by a repeated pressing and twisting at the open end into a conical die, by which means it is gradually brought to the proper form. A screw is afterwards formed for the stopper by the ordinary means.—*Scientific Journal.*

THE city of Rotterdam is to have a bridge over the river Meuse, 1,500 ft. long.

WHO INVENTED THE STEAMBOAT?

From "The Iron Age."

The question of who invented the steamboat could be correctly answered only by enumerating several projectors whose efforts succeeded each other during a period of three-fourths of a century. The propulsion of boats by paddle-wheels is said, indeed, to date back to the time of the Romans, but precisely in what way they applied the power is not known. As long ago as 1682 Prince Rupert, the courtly mechanician of the heyday of the Stuarts, propelled his barge in this way. In 1726, one Dr. Allen, printed a pamphlet in London, in which he proposed to urge a vessel forward by a jet of air or water ejected from a pipe at the stern. He thought that by using steam-power he could make 3 miles an hour in this way. In 1737, Jonathan Hulls published his invention, which may be considered the archetype of the modern steamboat. It had a paddle-wheel arranged at the stern, and worked by a steam-engine; but instead of the crank, the application of which to the steam-engine had not then been invented, Hulls employed a complicated set of devices for giving motion to the wheel. After this there was little or nothing suggested in the line of steam propulsion until 1782, when the Marquis de Jeoffroy tried a steamer on the river Loire in France. Instead of a paddle-wheel, he had the paddles arranged upon an endless belt that traversed 2 supporting pulleys, but the apparatus was not successful. Two years later, James Rumsey commenced experiments with a boat 80 ft. long, in which an engine worked a vertical pump that drew in water at the bow and ejected it at the stern. The reaction of the effluent water moved the vessel along at the rate of 4 miles an hour. This seems to have been a revival in some sort of Allen's plan; and substantially the same system has been frequently re-invented since, a recent and notable example of these jet propellers being found in the English vessel, the *Water Witch*. In 1786 John Fitch made public his project of moving vessels against wind and tide by fitting them with vibratory paddles worked by steam-power. There were 12 paddles, 6 on each side of the boat, one-half of those on either side working alternately with the other half of the number. The paddles were designed to have a stroke of 5½ ft., but it does not appear that the plan was ever subjected to actual trial. Fitch, however, did not rest contented with this plan, else he would never have been heard of afterward, but was also the inventor of a screw propeller, and also of the combination in one vessel of the screw and side-wheels—the principle of propulsion adopted in the *Great Eastern*. The screw-propeller, and mode of using it in connection with paddle-wheels, was shown by experiments in 1796, or 1797, on the Collect pond, a sheet of water that in those days rippled where the grim Egypt pile, the New York city "Tombs," now stands. The vessel is described as a common boat, 18 ft. long and 6 ft. wide, and steered at the bow. The steam boiler was constituted by a 12 gal. iron pot, with a lid made of a piece of plank firmly fastened down. The engine had 2 wooden cylinders, and the mechanical appliances for working the screw and paddle-wheels, although rude, were arranged with such effect that a speed of 6 miles an hour is said to have been obtained. The inventor, however, was too poor to continue his experiments, and too impatient of argument and contradiction to interest the incredulous moneyed men of the day in his enterprise. The boat, with a part of its machinery, was drawn up and left on the shore of the pond, and, piece by piece, this type of the future steam vessel fell to decay, and the children of the neighborhood gathered up its fragments and carried them home for kindling wood. A few years later, Fitch, a broken and embittered old man, with feeble health and ruined fortunes, poisoned himself with opium, and was buried in Bardstown, Ky. To this day no monument or headstone marks his resting place, but the fulfilment of his prophecies are shown wherever the steam-whistle sounds over the placid waters of rivers, or the turbulent foaming of the sea.

While Fitch and Rumsey were thus experimenting with steam propulsion, others were making trials in the same direction with more or less success. As an illus-

tration of the blunders that even truly great men will sometimes make, it may be noticed that about the year 1786, Dr. Franklin proposed to propel vessels by the direct action of steam upon the water, which was, of course, found to be utterly out of the question. About the same time, Oliver Evans advocated the employment of paddle-wheels, and a boat was run for a short time between Philadelphia and Bordentown, but no details of its means of propulsion have been handed down. In 1787, Mr. Patrick Miller, of Dalswinton, in Scotland, made a double vessel, moved by a paddle-wheel in the stern, and two years after constructed another 60 ft. long, that went at the rate of 7 miles an hour, but proved too weak to bear the action of the machinery. It is said that these experiments cost Miller upward of $150,000, for which he received no return whatever. A dozen years afterward, William Symington, who had made the steam-engines for Miller's boats, induced Lord Dundas to build a steam vessel for towing craft on the Forth and Clyde Canal. This, the *Charlotte Dundas*, dragged along 2 sloops of 70 tons burden each, against a strong head-wind, at a speed of 3½ miles an hour. The owners of the canal, however, refused to use this means of towing because of the liability of injuring the banks by the undulations of the water—the principal reason to this day why steam has not been applied in canal propulsion. From this time forward steam navigation began to assume a more promising aspect and more tangible shape. In 1804 John Stevens, of Hoboken, N. J., had a boat 24 ft. long fitted with a paddle-wheel at the stern, which, for short distances, made 8 miles an hour. The greatest benefit, however, conferred by Stevens upon the engineering world was in the invention of the tubular boiler—a principle of construction that has worked wonders in steam-generators for all purposes.

We now come to the efforts of Robert Fulton, a man who possessed business talent, and the faculty of mastering the details of whatever he undertook, in a no less degree than inventive skill. He left Philadelphia in 1786, and went to London, where, as early as 1793, he communicated with Earl Stanhope concerning steamboats—this nobleman being something of an enthusiast on the subject, and having a plan of his own, which has come to be known as that of the duck's-foot propeller. This was simply a kind of folding oar, which opened to act against the water when pushed outward, and closed when drawn back at the end of the stroke. After this, Fulton went to France, where he brought before Napoleon a method for blowing up the English ships; but, although he made an apparatus by which he was enabled to remain under water for a period of 4½ hours, he did not destroy a single vessel of the enemy. His journey to France, however, did him some good, for it was there that he became acquainted with Chancellor Livingston, who furnished the funds by which he was finally enabled to put his plans for steam propulsion into practice. Assisted by Livingston, he, in 1803, made experiments on the river Seine, with a paddle-wheel boat 60 ft. long. The results were so favorable that it was concluded to attempt without delay, the introduction of steam navigation on American waters. An engine was ordered from the English workshops of Boulton & Watt, and was duly forwarded to New York. In 1807 the *Clermont* was launched on the East River, and at once commenced running on the Hudson, between New York and Albany. Since then, until the present hour, there has not been a single day when vessels have not been propelled against wind and tide by the power of steam—the *Clermont*, having been, if not the earliest practical steam-boat, at least the first steam-vessel to establish a system of regular trips between different places.

Joseph Glynn, in his treatise on the power of water, gives a description of a turbine constructed by M. Fourneyron, at St. Blaise, in the Black Forest of Baden, about the year 1837, which worked under a head of 354 ft.; its diameter was 13 in., the face of the wheel, or depth of buckets, was .225, or less than a quarter of an inch; it made from 2,200 to 2,300 revolutions per minute. This turbine drove a cotton mill of 8,000 spindles with all the accessories.

A further improvement is contemplated in the streets of Paris, viz., the crossing of the streets through iron galleries, either above or below ground.

THE CORROSION OF SHIP-PLATES.

From "Engineering."

The application of steel to the construction of ships, which has of late years become one of the recognized channels of progress in marine engineering, has raised many questions, and has directed the attention of engineers and of steel-makers to many points of inquiry which were formerly considered of minor importance, and the investigation of which has been partly, if not entirely, neglected. The first argument in favor of steel, viz., the greater absolute strength, was of course so obvious as to admit of no discussion; but even on this head the question of "brittleness" was brought forward, and not until many thousands of tests and trials had proved the fact that steel, although of greater tenacity than iron, can be made of equal pliability and ductility as the softest iron, was this objection finally abandoned. But this was limited to the property of absolute tensile strength. The question remained open whether the resistance of steel plates to compression and to buckling is in equal proportion superior to that of wrought iron, as is the case with regard to the tensile strength. In this form the question was first raised in the columns of this paper by Mr. John Scott Russell, and a series of experiments conducted by Sir William Fairbairn, Mr. Kirkaldy, and others, have, in the course of the last few years, given satisfactory evidence upon this point. But there still remain some questions of another character, which are of equal importance as affecting the durability of the materials employed in ship-building. These refer to the chemical properties of the materials, viz., to their power of resisting corrosion when exposed to the action of the atmosphere, and to the still more powerful corrosive action of sea-water. It has been generally admitted that the action of diluted acids, and of sea-water, is more rapid upon steel than upon wrought iron; but a series of experiments made by Mr. Henry Bessemer some years ago, showed that there was an important point in favor of steel, viz., the uniform action of the chemicals upon the whole exposed surface of the steel plate, as compared with the irregular local corrosion concentrated upon certain places of the iron plate. Mr. Bessemer immersed pieces of steel plates and of iron plates in vessels which were filled with diluted acids, and with solutions of different salts. From time to time the plates were removed and examined. The action of the chemicals upon the iron and steel was strikingly different. The steel plate showed an uniform, close-grained texture all over its surface, and under the microscope the steel surface appeared of a homogeneous, crystalline structure. In the case of the iron plate, on the other hand, the chemical action had made more rapid progress at all the minute fissures and openings which represent the welds or the interposed layers of oxides or slags existing between the individual crystals of the wrought iron; and the appearance even to the naked eye showed that peculiar irregularity of surface which is frequently produced upon iron in the process of etching or "damascening." The microscope still further disclosed that the wrought-iron surface was furrowed to a greater, or less depth in certain places, upon which the chemical action seemed to have concentrated its effect, and which therefore formed points of weakness, the existence of which in a plate would be far more dangerous than the corrosion of steel, which spreads equally over the whole surface. Mr. Bessemer's experiments, however, did not touch upon the relative quantity of the corrosive action upon iron and steel. Upon this point some very interesting experiments have been recently carried out in France at the works of the Terrenoire Company, near St. Etienne. The Terrenoire Company are well known as the first makers of Bessemer steel plates in France, and in consequence of this position the managers of the Terrenoire Works had more than an ordinary interest in trying to establish, by direct experiment, the relative quantities of the corrosive action upon iron plates and steel plates which is effected by sea-water. These experiments were made under the direction of M. A. Jullien, the managing director of the company, by M. Jules Euverte, the manager, and M. Paul Lemonnier, assistant manager of the works. Samples of plates

were cut to exactly similar dimensions, and carefully weighed. These samples were plates of best wrought iron, of hard Bessemer steel, and of the softest kinds of Bessemer steel, particularly those qualities which are made at Terrenoire for boiler plates, without spiegeleisen, by means of Mr. Henderson's well-known alloy of ferromanganese. These samples were immersed in sea-water, and the effect of the chemical action was put to an immediate quantitative test by means of a galvanometer. The plate was connected with one of the galvanometer wires, and the other, which carried a piece of platinum at the end, was immersed in the sea-water without touching the steel plate. This established a complete galvanic battery, of which the plate under test was the only variable element (since the same galvanometer and the same platinum piece was applied to each test plate). The amount of electric force which was measurable by the galvanometer was therefore in direct proportion to the quantity of chemical action which took place between the sea-water and the plate, and the indication of the galvanometer gave therefore the exact proportionate amount of corrosive effect produced by the sea-water upon each of the plates. The experiments at Terrenoire have confirmed the fact that the corrosion of steel containing more than ½ per cent. of carbon is more intense than that of wrought-iron, but the corrosion of the softest kinds of steel containing from ½ per cent of carbon downward is *less* than that of wrought-iron. In fact the amount of corrosion of different kinds of steel seems to follow the exact proportion of the percentage of carbon contained in the metal. The relative quantities as read off the galvanometer when some of the most characteristic specimens were under test were as follows:

Corrosion of steel containing 1 per cent. carbon	80.
Corrosion of wrought-iron plate	65.
Corrosion of soft Bessemer steel plate	55.

The evidence of these galvanometric tests has been still further corroborated by keeping the different plates immersed in sea-water for several months, and ascertaining the loss of weight of the plates regularly every week. The result of this prolonged experiment showed an exact coincidence of the proportionate weights with those indicated by the galvanometer. The regularity is so great that the same galvanometer always indicates the same figures when applied to the plate after a considerable lapse of time.

The experiments of the Terrenoire Works show in a very conclusive manner that soft steel plates, such as are usually—and ought to be always—employed in ship-building, are *less* liable to suffer from the corrosive action of the sea-water than iron plates. The advantage of the steel plates previously pointed out by Mr. Bessemer is, therefore, still further enhanced by this newly discovered superior resistance to corrosion, which is a property of the softest kinds of steel.

Observations on Sound in the Lake Tunnel at Chicago.—The Eighth Annual Report of the Board of Public Works, of the city of Chicago, in giving a history of the lake tunnel, says that observations on sound were frequently made during the progress of the work. The first distinct notice of anything of this kind was when the tunnel had been made 100 yards from the land shaft. Just above the tunnel is the breakwater inclosing the inlet basin. The outside of the breakwater consists of round piles, laced from 1 to 2 ft. apart. The waves could be distinctly heard in the tunnel below, striking those piles through 60 ft. of earth. The next observation was the passing of propellers and tugs, when the tunnel reached half a mile or more out. The different noises made by a vessel or engine passing overhead could be heard as distinctly through 30 to 40 ft. of earth as on the surface of the water. It was considered a matter of much interest to determine how far sound could be heard through the clay. The miners thought it could not be more than 150 to 200 ft. In order to be certain, observations were made when the faces were 800 ft. apart, and sounds of blows of iron on stone or iron in the clay, but not on the clay itself, could be heard with great distinctness. Whether the sounds passed through 800 ft. of clay, or first through 30 ft. of clay, then through 800 ft. of water and then through 30 ft. of clay, is a question—probably the latter.

There are no fewer than 241 Hindoo temples and Mohammedan mosques in Calcutta alone.

THE COAL FIELDS OF THE NORTH PACIFIC.

From "The Mining Journal."

The coal supply, no matter whence that supply is derived, is a subject in which every one is interested, and accounts of new fields, or those with which we are but imperfectly acquainted, are particularly acceptable. For this reason the paper "On the Geographical Distribution and Physical Caracteristics of the Coal Fields of the North Pacific Coast," read before the Edinburgh Geological Society, fairly claims favorable mention. The position of the author, Mr. Robert Brown, F. R. G. S., as commander and Government agent of the first Vancouver exploring expedition, is a sufficient guarantee for the value of his opinion. He explains that extending from California to the borders of Alaska are three coal fields, belonging respectively to the Tertiary, Secondary, and Palæozoic ages, the latter being situated, as far as yet known, only in the Queen Charlotte Islands, off the northern coast of British Columbia, the exact age being as yet undetermined, though the coal is anthracite, and is, in all probability, Palæozoic. The other two coal fields are situated, as regards each other, from south to north, in the order of their age. The Tertiary extends from California northward, and through Oregon and Washington Territory, impinging on the southern end of Vancouver Island and British Columbia, and extending, with some interruptions, right across the Rocky Mountains, the Miocene coals of Missouri being apparently only a continuation of these same beds. The secondary beds, on the other hand, on the North Pacific coast, are confined to the Island of Vancouver, though in all probability they are also a continuation of the cretaceous strata of Missouri.

With regard to the Tertiary coals of the North Pacific, Mr. Brown states that the lignitic beds are associated with shales and sandstones alternately, and the contained fossils show it to be of Miocene age throughout. The coal from it is of a very uniform character, burning freely, but leaving behind much slag and ash; and in many cases, though giving out a strong heat, unsuitable for domestic purposes, on account of its sulphurous character. It has, however, been wrought at various places thoughout its extent, and is at present being mined for commercial purposes at several localities—Monte Diabolo, California; Coose Bay, Oregon; Clallam Bay, opposite Vancouver Island; Bellingham Bay, and elsewhere. Regarding the quality of the coal it is difficult to form an estimate, from the often very partial reports of interested parties. It is, however, said that the clean picked coal gives very little ash, burns with a clear bright flame, and gives out considerable heat. Some of the large lumps contain veins of sand-stone, varying from ½ to 1½ in., and to this possibly may be attributed the great amount of "clinker" which it forms on the furnace bars. It is only just to say that all hitherto tried for steaming purposes has been merely surface coal, and, therefore, of inferior quality. The coal itself is hard, giving a brown lignite-like appearance on being scratched, shining equal to the appearance of anthracite, and breaking in small cubical fragments.

The valley between Olympia and the Columbia river, generally known as the Cowlitz Portage, appears to be a coal basin to some extent. Coal has been found not far from the celebrated Mound Prairie, about half-way over, and on the Monticello and Columbia rivers, but in such small quantities as hitherto to have rendered it unworthy of being wrought. If coal could be found in proximity to the splendid but undeveloped iron mines of the Columbia, the result would be of great commercial importance. Near the Squak prairie, 25 miles from the village of Seattle, coal is seen to crop out on the side of the mountain in seams of 2 or 3 ft. in thickness, but as its position would render its transportation expensive, it creates but little interest. On the Stoluchwamish river, north-east of Seattle, a thin seam of coal has been found, but is not wrought. It is only when we arrive at Bellingham Bay, situated a few miles south of the British boundary line (latitude 49 deg. north) that we find the coal of sufficient thickness and proximity to the sea to render it of sufficient importance to be mined. Here a company have been at work for a number of years, and

export a considerable amount of coal to the San Francisco market. It is of the same quality as the other tertiary coals of the coast, and is generally mixed with a better class of coals before being used. The mines are very full of fire-damp, while the various mines of cretaceous age are entirely free from this.

The whole coast of Vancouver Island, on the east coast, north of Chemainos, and round to Koskeemo Sound, on the westward, and for some distance into the interior, is bounded by a belt of carboniferous strata, composed of sandstones, shales, and coarse gravel-stone conglomerates, interstratified with which are beds of coal of much superior character to any hitherto described. These beds, from the fossils they contain, appear to be cretaceous. Everywhere the strata named form a characteristic accompaniment of the coal, especially the coarse conglomerate just named; and nearly everywhere it is underlaid by one or more seams of coal. Hitherto we have only found it cropping out at some points of the circuit named, though it may reasonably be supposed yet to be found on the opposite shores of British Columbia. The wall of the deep fiords indenting this part of the coast everywhere are, however, in most cases composed of trap and other igneous rocks, and whatever sedimentary rocks may at one time have reposed on their flanks have now been washed off by the action of denudation.

The Nanaimo coal is bright, tolerably hard, and not unlike some of the best qualities of English or Welsh coal in appearance. It burns freely, with a good heat, but produces a great amount of ash. It is universally used by all Her Majesty's ships on the coast, and by all of the colonial and other steamers plying on the coast. It is highly valued as fuel for domestic purposes, both in Victoria, San Francisco, and other towns. Gas is manufactured from it at Victoria of good illuminating quality. No fire-damp has hitherto been found in the mine. The coal is easily wrought, a miner being able, under favorable circumstances, to take out about 2½ tons in his working time, which, at the rate of 5s. per ton for his clean dressed coal, will net him about 11s. per diem. Most of the miners are from Scotland or Lancashire, and generally employ an Indian to clean their coal for them. They rarely work a full day, preferring to earn a constant moderate wages rather than run the chance of getting the price lowered by their producing the coal in greater quantities.

North of Vancouver Island, at a distance of from 20 to 40 miles from land, lie the Queen Charlotte Islands, consisting of a group of three main islands, with a number of lesser islets lying off the shore. These islands are, in general, densely covered with forest, and permeated by inlets of the sea; but their interior is entirely unexplored. They are, however, rich in copper and other minerals; and gold quartz, of a surprisingly rich description, was discovered in one spot here about 15 years ago. A hot spring is found at the southern end of the most southerly island; but there is no volcano here, as Mr. Mallet erroneously places on his map of earthquake phenomena and volcanoes. The island, though so near the mainland, differs remarkably in having no deer, wolves, or raccoons—animals extremely abundant on the opposite shores of British Columbia. The coasts are inhabited by several tribes of a very fine-looking, stalwart, and warlike race, generally known under the name of Hydahs. There are no white settlements on these islands, but they are occasionally visited by well-armed traders, for the natives bear the reputation of being anything but a remarkably docile race, a reputation earned by many lawless and cruel acts.

Of late years coal has been discovered on these islands of a very superior quality. Accordingly, in the spring of 1866 I took advantage of a party of miners going up to "prospect" this coal to pay a visit to the islands. I saw no appearance of coal—or, indeed, of any sedimentary rock—along the whole coast of British Columbia until we arrived at these islands. Here the coal crops out in various places on the islands, but its chief development is at Skidgate Bay, where I passed some weeks. The whole of the beds seem to have been thrown out of position by erupted masses of felspathic trap, on the flanks of which the beds reposed, and by which the strata (sandstone, etc.) have been much metamorphosed, and the coal altered. Two rival parties of miners were there prospecting, and one of them had driven an adit into the hill side some 200 or 300 ft. above the sea level. Here they had

gone through a great bed of coarse conglomerate—a fine hard slate—when the coal was reached. This conglomerate was in every respect similar to that associated with the Nanaimo coal fields, but the slate was peculiar. It is a close-grained, lustreless material, breaking in cuboidal fragments, and easily wrought. The coal was apparently of the nature of a true anthracite, with a bright lustre, hard, and giving out an intense heat. Recent efforts have been more satisfactory than the earlier ones, but Mr. Brown thinks that the working of the coal will always be difficult, on account of the numerous faults, dykes, and other disturbances.

SOME DIFFICULTIES IN THE RECEIVED VIEWS OF FLUID FRICTION.

By MR. W. FROUDE.*

From "The Engineer."

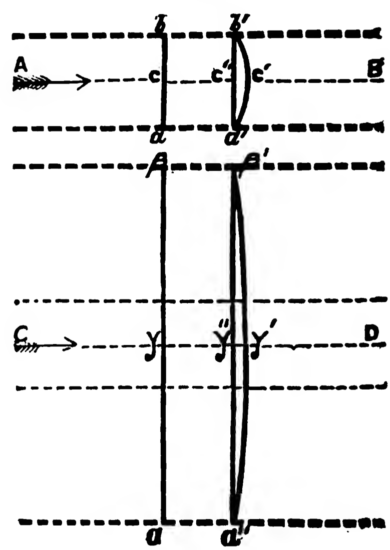
The very great variations in the resistance offered to the flow of water through the main of the Torquay water supply, arising from apparently small variations in the roughness of the interior surface, have led me to think that our views of the character of that action which is commonly termed "fluid friction," or "skin resistance," requires further investigation, and perhaps material revision.

The accredited laws which are held to govern the resistance arising from this action are based on the following considerations: (1) That the resistance offered by each square foot of rubbing surface in a given plane moving edgewise, is the same throughout the plane; (2) That it is as the square of the velocity of the surface through the surrounding fluid, or of the surrounding fluid past the surface. And this relation is usually expressed by a simple coefficient, the value of which is known to vary somewhat with the quality of the surface, being increased by its roughness, and is held to be somewhat less for high velocities than for low.

If we express the friction by $f=k\,v^2\,a$, (v) being the velocity in feet per second, and (a) the friction bearing area in square feet, the value of (k) as deduced from Beaufoy's experiments with a smooth painted plank moving through open water, is 0.0034, while Professor Rankine takes it at about the same value, or 0.0036 for clean painted iron. And as deduced from Professor Rankine's rules for the flow of water through pipes of cast-iron, its value appears to vary between 0.0092 for velocities of about 1 ft. per second, and 0.0056 for velocities of about 4 ft. per second.

The excess which is observed in comparing the coefficient of resistance suitable for the internal surface of a pipe, with that suitable for smooth surfaces in open water, represents the circumstances that the central or maximum velocity of the contents of a pipe considerably exceeds their mean velocity; and that a cast-iron surface—that commonly referred to in pipes—is probably inferior in smoothness to a painted surface, while the excess in the coefficient appropriated to the higher velocity, represents the probability that the imperfect fluidity of water is more felt when the velocity is small.

Fig. 1.



The *rationale*, if I may use the term, by which the flow of water through a pipe is deduced from this coefficient of friction, and the internal area of the pipe, involves the assumption that one and the same

* British Association.

multiple of the mean velocity, is equally applicable to all pipes of whatever diameter, as the effective velocity in virtue of which the coefficient is to be applied.

This assumption will now determine the resistance which each length-unit of pipe, of given diameter, will offer in virtue of the velocity of flow; and if the mean declivity, or hydraulic gradient, be also given, the velocity must be such that this resistance shall exactly balance the force which the weight of the corresponding length-unit of internal water column exerts along the pipe in virtue of the gradient.

The usual formulæ are thus deduced, which give the mean velocity as proportioned to the square root of the diameter and the square root of the gradient, and the delivery per minute as proportioned to the power $\frac{5}{2}$ of the diameter and the square root of the fall.

This mode of viewing the question does not essentially differ from that of supposing the enclosed column of water to glide bodily along the interior of the pipe, and the resistance to be delivered at a definite rubbing surface as with solid friction, depending, however, not on pressure of contact, but on velocity of gliding. And the supposition seems to lead to some irreconcilable consequences.

The character of the motion involved in it may be geometrically represented as follows :

Let A B, Fig. 1, be a portion of pipe having a diameter = unity, and let the water within it be flowing in obedience to some given hydraulic gradient, and therefore with some definite mean and effective velocities, say V and V′.

Let $a\ c\ b$ be the line occupied at any moment by a series of diametrically placed particles ; then the supposition which we are examining will be represented by assigning to these particles, after the lapse of a definite unit of time, some new position, $a'\ c'\ b'$, in which $a\ a'$ and $b\ b'$ will represent the effective velocity, and the ordinates of the curvilinear area $a'\ c'\ b'\ c''$ will represent the excess of the mean over the effective velocity, or $(V-V')$.

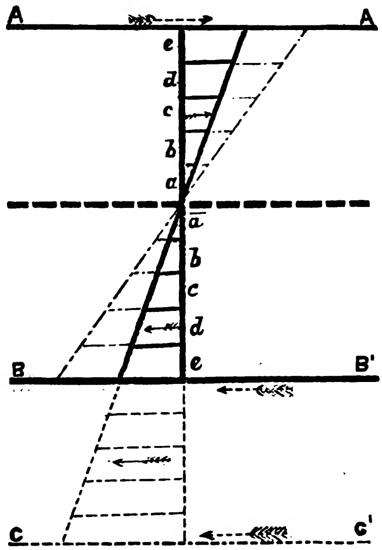
Let us now compare with this the state of things which, on the same supposition, will similarly ensue in a pipe of larger, say quadrupled diameter, under the same hydraulic gradient, and let this pipe be represented by C D.

In this case, since by the formula the velocity is as the square root of the diameter, the effective and the mean velocities will alike be doubled; and a series of displacements throughout, equal to those which take place during the unit of time in the small pipe, will take place during half that unit in the larger pipe.

Forming a diagram on this basis, we shall have $a'\ a' = a'\ a'$, and so on throughout.

Now, it appears to me difficult to believe that the particles along the line

FIG. 2.



$\alpha'\ \beta'\ \gamma'$, which has a quadrupled length, and therefore presumably a greater mobility, in the larger pipe, will not be bent forward in the middle through a wider space than the particles along $a'\ c'\ b'$ have been bent forward in the smaller pipe, which are all so much nearer to the restraining surface. Or to place the difficulty in a more definite shape, if we mentally picture to ourselves within the larger tube the conditions of a central column of water having the same diameter as the smaller tube, as indicated by the dotted lines, I do not see why we ought not to expect that central column to glide forward as rapidly past the moving particles which immediately surround it, as the similarly placed particles in the smaller tube glide forward within the fixed sur-

face of the tube; unless it be more difficult for particles of fluid to slide past one another, than for them to slide past a fixed surface.

Viewing the matter in this light, I am led to the conclusion that there is no real justification for the idea of discontinuity in the velocity where the water meets the surface, and that the "state of motion" must really consist of a graduated series of velocities increasing from the circumference to the centre, annulus sliding within annulus, and the resisting force being a function, not of some arbitrarily assumed effective absolute velocity, but of the relative velocities of contiguous particles.

This crude suggestion may be framed into a more intelligible hypothesis, if embodied in a diagram which presents it under a somewhat different aspect.

Let A A′, B B′, Fig. 2, be two planes of infinite extension, guided so as to move edgewise parallel to one another, and moving with equal uniform velocities in opposite directions, the intervening space being filled with water.

Then when the state of intervening motions and forces has become established, there are several consequences of the supposition which may at once be regarded as certain.

In the first place, each plane will experience a definite resistance per square foot the same throughout along its line of action, and the same for both; and these equal and opposing forces must be somehow transmitted from the one plane to the other, square foot by square foot, through the intervening water, maintaining in it a definite constant state of motion.

In the next place, the particles in absolute contact with each plane, will be moving with the velocity of the plane.

Further, the line of particles midway between the planes must be stationary, since it is symmetrically situated with reference to the two equal and opposing motions and forces.

And lastly, any intervening particle on either side of the central line must be moving with some graduated velocity, accordant with that of the plane to which it is nearest.

Now, if the planes be so free from roughness as to be incapable of imparting lateral impulse to the water, it seems clear that the growth of velocity on either side of the central line must be uniform, as we recede from the centre. For if we imagine the intervening fluid as consisting of successive parallel layers of equal thickness, each layer must be so moving past the contiguous layer, as to transmit to it, square foot by square foot, that identical force which is experienced as resistance by the boundary planes. And it would seem that therefore layer *a* must be passing layer *b* as fast as layer *b* is passing layer *a*, and so on throughout.

The ordinates of the triangular spaces shown on either side of the centre, will thus represent the respective velocities of the corresponding particles.

If this view be sound, it follows that, were we to establish a third plane B B′, making the distance B C (say) $= \frac{1}{2}$ A B, and were we to assign to this plane a conformable velocity double that of the plane C C′, and let the intervening space be filled with fluid, carrying on the same established growth of velocity as before, in a continued series to the outer plane, we should, under these circumstances, transmit to that outer plane exactly the same force per square foot as that experienced on the original planes; and the plane B B′ would meanwhile assume merely the condition of one of the intervening layers of fluid, becoming a mere neutral instrument in the transmission of force and motion.

We should thus have, on the plane C C′, moving with an absolutely double velocity, only the same velocity relatively to the contiguous water, and only the same force per square foot, as on the plane A A, moving with the single velocity.

Thus it would seem that the so-called force of friction may be more properly regarded rather as "resistance to deformation" than as "friction," in the usual sense of the term; and that its measure depends, not on the absolute velocity of the moving solid surface which initiates the deformation, but on the rate at which the deformation is transmitted from layer to layer.

Thus, though the double velocity of the plane C C subjects it to no enhanced resistance, since the rate of transmitted deformation is in that case unchanged, yet if we had doubled the velocities of the two original planes A A′, B B′, we *should* have enhanced the rate of transmitted deformation, and in some degree, as yet unknown,

we should have also enhanced the resistance.

We thus have to regard the resistance as governed by what we may term the "angle of deformation," say (ϕ), which might be defined as the change of angular position which, in a given infinitesimal unit of time, the relative motions of two closely contiguous particles impose on a line which at the commencement of the interval was at right angles to the line of motion, thus expressing the space by which, during the assumed interval of time $d\,t$, any particle in the line E E, Fig. 3, is carried past its opposite particle in D D, in terms of the interval between the lines. The resistance will probably be some function of (φ).

In the case of the infinitely extended parallel planes just now considered, (ϕ) was constant throughout the whole intervening space. But in the case where a plane is being intruded into a volume of stationary particles, (ϕ) will be found to vary in terms of (h), the lateral distance between the particles concerned and the plane, as well as in terms of (s), the distance along the plane. And at any distance along the plane $\left(\frac{d\,\phi}{d\,h}\right)$ will contain a measure of the varying force which penetrates the surrounding fluid, so far as this has become affected by the motion, and will thus also contain a measure of the accelerating force which actuates the intervening layer; because it expresses how much greater force is dragging the layer forward on one face, than is dragging it backward on the other. This state of things is represented in Fig. 4.

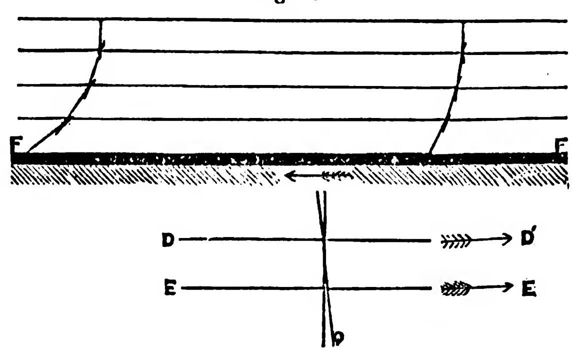
From this mode of viewing the subject, it would follow that when a plane of considerable length is moving edgewise through undisturbed water, a square foot of surface at its head-end must experience a greater resistance than one near its stern-end, because the force exerted by the head-end has already imposed force and motion on the particles which flow past it, and the state of motion must have spread into the surrounding fluid, so that at the stern-end the valves of (ϕ) and of $\left(\frac{d\,\phi}{d\,h}\right)$ will both be less than at the head-end.

Were the law of force in terms of (ϕ) known, it would be possible to construct a differential equation which would show the rate of accumulation of the current along the side of the plane, and its penetration into the surrounding fluid.

That some such correction of the usual views on the subject is required, appears to me to be inevitably involved in the fact that the growing current I refer to, visibly as well as necessarily exists.

It seems a paradox to say that the stern-end can experience as much force per sq. ft. as the head-end, when there exists a favorable current of considerable velocity and of considerable thickness alongside the former, which has no existence alongside the latter. It is equivalent to saying that were we to plunge a plane edgewise into this favoring current it would experience as much resistance as if we plunged it into the as yet undisturbed water outside the current.

Fig. 3.



I may add that of all the conditions affecting the resistance of a ship, this alone seems to me to perplex the comparison between the resistance of a ship and of a model similar to the ship; but it must equally perplex the comparison between the resistance of similar ships of different sizes; and the law which governs the condition will be readily determinable by experiment.

The state of the works on Mont Cenis Tunnel, Jan. 1, was as follows: From the south, 20,510 ft. had been executed, and from the north, 14,953½ ft., making a total of 35,463½ ft., and leaving 4,914 ft. to be accomplished.

THE LOUISVILLE BRIDGE.

Abstract from "The Louisville Commercial."

The importance of this enterprise will be better recognized when it is known that it connects three great distinct systems of railroad. 1st. Being nearly on the direct lines between Pensacola and Mobile and Chicago, it completes the directly middle and South lines. 2d. It joins the missing connection of Memphis, New Orleans and the Lower Mississippi Valley and Texas with New York, Philadelphia, Baltimore, Washington, and the Northeastern States, thus joining a continuous line of railroad from the Southwest to the Northeast. 3d. It furnishes the best link in the chain of roads connecting Savannah, Charleston, Wilmington, Norfolk, and the principal cities of the Southern States, with St. Louis, Quincy, Burlington, Rock Island, and the lines starting from various points on the upper lines and rivers, and penetrating the far West to the Pacific Railway.

Louisville is the central point in the line of the unbroken rail routes between the Southeast and Northwest. Probably at no other point on the continent would the erection of a bridge furnish such facilities for travel and commerce. The importance of this route, socially and commercially, cannot be overrated, but might be reverted to at length. By it people are brought into more frequent and advantageous contact, heretofore separated by the river, and subject to the slow and uncertain movements of ferries, which at times, during the low water of summer, are either obliged to suspend altogether their trips, or make them at such lengthened intervals as to render it insufferable for any person to whom time is of any importance, to endure them, and which for a week at a time during the winter season have been obliged to tie up for fear of ice.

By these, as would have been thought a few years ago insurmountable obstacles, the cities of Louisville, New Albany, and Jeffersonville, have been separated.

Bridge engineers, fortunately, have for the last ten years been rapidly developing the science of bridging over large streams, and during the past three years two members of the profession have, by their genius, energy, and perseverance, overcome all obstacles, and erected this crowning monument to engineering skill.

LOCATION OF THE BRIDGE.

Previous to the organization of the company during the fall of 1866, preliminary surveys were made of the several crossings at Jeffersonville, Elm Tree Garden, and New Albany, with the view of ascertaining the best location for the proposed bridge, and its connection with the Louisville and Nashville Railroad and Jeffersonville and Indianapolis Railroad.

Early in April, Mr. F. W. Vaughan, assistant engineer, commenced the surveys for the final location, and made a series of observations to determine the direction of the currents at the various stages of the river. On the 15th of June a report was submitted to the Board, and the final location of the bridge determined. The location may be described as follows:

The track connecting the Louisville and Nashville Railroad with the bridge leaves the yard of that railroad north of the engine house near Tenth street. Entering Maple street, it passes to Fourteenth street, and thence to Portland avenue. From the avenue the track crosses to High street, in a prolongation line of Fourteenth street, then curving to the right, crosses the river at right angles to the direction of the currents, striking the Indiana shore at a point 1,500 ft. below Smith & Smyser's mill; from thence the line continues in the same direction in which it crossed the river until it reaches the dirt road between New Albany and Jeffersonville, where it commences to curve to the right, entering Ninth street in Jeffersonville, through which it continues to the connecting link with the Jeffersonville Railroad. The total length of the connecting link between the Louisville and Nashville Railroad and Jeffersonville Railroad is 3 miles and 7-10.

GRADES.

The grade of the track approaching the bridge on the Kentucky side corresponds with that of High street at the point where the crossing is made; from this point it ascends at the rate of 76 ft. per mile,

striking the first span of the bridge at an elevation of 63 ft. above low-water, and continues at the same rate until pier No. 13, on the south side of the middle channel, is reached, at a distance of 2,500 ft. from High street, and 2,196 ft. from the face of the southern abutment. Here the grade has an elevation above low-water of 95 ft. From here the grade is level for a distance of 2,243 ft., till pier No. 21 is reached, on the north side of the Indiana channel. The elevation above low-water in this channel is 101½ ft. (the low watermark being 6½ ft. lower than in the middle channel), and from here the grade descends at the rate of 70 ft. per mile, reaching the southern abutment at a distance of 790 ft. from pier No. 21. and at an elevation of 35 ft. above the natural surface of the ground. The grade of the Indiana approach continues to descend at the same rate, reaching the surface of the ground 2,500 ft. from the abutment. This approach consists of an earth embankment.

ARRANGEMENT OF SPANS.

The superstructure is placed below the grade of track, except over the middle and Indiana channels. The lowest point of the superstructure at the middle channel is 90 ft. above low-water mark, and over the Indiana channel 96½ ft.

The length of each span, counting from the Kentucky to the Indiana shore, and the entire length of the superstructure, including abutments, will be seen from the following table, the length of the spans are from centre to centre of piers :

LENGTH OF THE SUPERSTRUCTURE.

	Feet.
Kentucky abutment	35.0
Two spans of 50 ft. each	100.0
One pivot draw of 264 ft. over canal	264.0
Four spans of 149.6 ft	598.4
Two spans of 180.0 ft	360.0
Two spans of 210.0 ft	420.0
Two spans of 227.0 ft	454.0
One span of 370.0 ft	370.0
Six spans of 245.5 ft	1,473.0
One span of 400.0 ft	400.0
Three spans of 180 ft	540.0
One span of 149.6 ft	149.6
One span of 100.0 ft	100.0
Indiana abutment	35.0
Total	5,299.0

THE FIRST STONE LAID.

On the 1st day of August the first stone was pronounced "well and truly set" in pier No. 10, by Mr. Hamilton, President of the Bridge Company.

The masonry was carried on in view of building the piers next to the Kentucky shore high enough to make their completion practicable during the high stages of water incident to the spring months, so that the erection of the superstructure could be commenced at the earliest possible moment. This point secured, it was determined to take advantage of the unusual low water, by putting in the most difficult foundations in the rapid water of the falls. This attempt was successful, three of the most difficult foundations being secured between the 1st of October and the 1st of December, and had it not been for an unexpected rise in the river, which carried away part of the temporary trestle and the coffer dam of the fourth pier, all the foundations on the rapids would have been secured.

Of the 27 piers, there were 17 started, from 1 to 14 inclusive, and 18, 19 and 20; of the remaining, 2 only presented difficulties. A suspension of laying the stone took place during the winter months, but the contractors improved the time in quarrying and cutting a large quantity of stone to be used when spring opened.

MASONRY CONSTRUCTION TRANSFERRED TO THE COMPANY.

During the first part of the season of 1868, the work was carried on as usual by contractors, but being conducted so slowly, the company became dissatisfied and took the contract from their hands, and on the 1st of September satisfactory arrangements were made to transfer the construction of the masonry to the Bridge Company. In accordance with this arrangement the contractors turned over to the company all the tools and appliances used on the work.

Soon after the transfer took place, an unusual rise in the river washed away all the building derricks, the temporary track for transporting stone for the piers, and caused much other damage. On the 1st of October not a derrick remained standing in the river. This state of affairs called forth the energy of the engineers, and they were equal to the task before them, for in three weeks a new track was constructed across the river, derricks and derrick boats built, and the work progressed simultaneously on ten piers.

An attempt was now made to secure the foundation for Pier No. 17, but, owing to unexpected difficulties, the lateness of the season, and a sudden rise in the river, it was abandoned. The foundation of Pier No. 21 was secured, after surmounting great difficulties, as well as those of all the remaining piers, so that at the close of the season of 1868, 16 piers were entirely completed, and of the remaining 11 all were started, excepting No. 17.

The laying of stone was suspended December 20, 1868, and resumed in March, 1869. For 4 months the stage of water in the river enabled the company to supply the material by barges.

COMPLETION OF THE MASONRY.

The water falling in its summer stage in July, a temporary track was constructed for supplying the piers with stone, and on the 24th of November, 1869, the last stone was laid in Pier No. 19.

The masonry consists of two abutments and twenty-seven piers, comprising, in the aggregate, 30,500 cubic yards of lime-stone each, which, for beauty and excellence, both in construction and material, is believed to be unsurpassed. The piers vary in height from 60 to 105 ft., and are laid in hydraulic cement, manufactured in the vicinity of Louisville. These huge piers rest on the solid rock bed on the river, the foundations of some of which have been secured with great difficulty, on account of the immense body of water rushing over them, and the tendency of springs to break forth in the coffer dams.

From the time of the transfer of the masonry contract to the company, until the completion of the work, it has been under the personal superintendence of Mr. Vaughan. Mr. Flannery remained on the work several months after the withdrawal of his firm, as superintendent of masonry, and, upon being called to a more profitable field of labor, was succeeded by Mr. M. J. O'Connor, who remained till the completion of the masonry. To these gentlemen is due great praise for the faithful, energetic and skilful manner in which they performed the difficult duties imposed upon them by their respective positions.

SUPERSTRUCTURE OF THE BRIDGE.

With the exception of the portion spanning the channels, all of the superstructure is placed below the grade of the road. The below grade or deck portion is constructed of Fink's Suspension Truss. The spans over the channels are constructed after plans arranged specially for this work. The whole superstructure is of iron (except the flooring) and consists of 27 spans, varying in length from 50 to 400 ft., the channel spans being 370 and 400 ft. in length, and no larger work has ever been constructed on this continent.

The superstructure, with a few exceptions, is built entirely of wrought-iron. The chords and brace shoes in the long spans, and the chords and post shoes in the suspension trusses, are of cast-iron. Throughout the construction of the bridge the Phœnix wrought-iron columns have been used exclusively for posts and braces.

THE USES OF THE BRIDGE.

When the bridge is pronounced complete in every respect it will have foot-walks 4 feet in width on either side, protected by hand railings. There is a single track for railroad travel over the bridge; the distance between the foot-walks, 20 ft. 6 in., can be floored over, and used as a carriage or wagon track when not used by trains or railroad purposes.

The superstructure is proportioned for a maximum movable load of 2,240 lbs. per lineal foot, which can only be brought on it by a train of locomotives coupled together. Seven times this maximum load is calculated to be the weight necessary to break it down in all ordinary railroads. The load that it will be called upon to sustain is at most two-thirds of this maximum, so that even more than sevenfold is provided for accidents.

The weight of the iron in the superstructure is immense, and the wrought and cast-iron together will weigh 8,723,000 lbs. There has been 639,000 feet of timber used in the flooring, hand-rails and rail-joists.

WORK ON SUPERSTRUCTURE COMMENCED.

The engineers of the Bridge Company commenced their plans of the superstructure in the fall of 1867, and the contracts for carrying out the same were awarded to the Louisville Bridge and Iron Company, who obligated themselves to furnish the iron-work, ready for erection, from drawings and plans furnished by the

bridge engineers, who superintended its erection.

Great credit is due the Louisville Bridge and Iron Company for the promptness and fidelity with which they have fulfilled this great contract. The most available skill was brought into requisition to make this work unsurpassed in beauty, strength and durability, and their success has been complete, as a thorough examination of the work proves.

The whole of this immense quantity of iron material used, with the exception of the wrought-iron columns, was manufactured in Louisville and New Albany. The Ohio Falls Nail Works of New Albany furnished the wrought-iron proper.

DELIVERY OF THE WORK.

The contractors delivered the canal draw in June, 1868, and on the 3d day of July it was swung in place. As fast as the masonry would permit, the succeeding spans were put in place, and by the close of the season eleven spans on the Kentucky side, and one on the Indiana side, were in position.

The work progressed at each end during the last season simultaneously. On the first day of December the work was so far completed that all the spans were in place except the one between piers 19 and 20, for which the false work was ready, and, but for an unforeseen accident, would have been completed two months earlier.

The disaster, it will be remembered, occurred in the following manner: A steamboat drawing a tow going over the falls in a fog missed the channel, and striking the false work carried it away, taking with it the cribs that supported the trestles, leaving a wide gap at the bottom of which was a large body of water, 16 ft. deep, running at a rapid rate. In the centre of this space was sunk a crib upon which three trestles were erected, the centre one being vertical and those on either side inclining toward piers 19 and 20. Leaning trestles were built from the bottom of these piers, which were connected at the top. On this false work, after a severe trial by freshet, the last span was joined and swung into place February 1st, 1870. Some time was required to change the gauge, but on the evening of the 12th of February, 1870, the first train passed over, consisting of an engine and 24 flat cars.

Since that time trains have been passing at times as required, over the bridge, which has been tested by the severest trials, proving in a most satisfactory manner its entire reliability.

The erection of the superstructure this past summer was a monument in itself of engineering skill and undaunted energy. The span over the Indiana channel was erected over the water, 10 ft. deep, rushing at the rate of 18 miles an hour; some of the pieces weighing five tons, required to be hoisted to their places 160 ft. above the bed of the river. In all cases foundations for the false work were obtained by sinking cribs filled with stone.

TO MAKE SCREWS HOLD.—Where screws are driven into soft wood, subjected to considerable strain, they are very likely to work loose; and many times it is very difficult to make them hold. In such cases we have always found the use of glue profitable. Prepare the glue thick; immerse a stick about half the size of the screw, and drive it home as quick as possible. When there is some article of furniture to be repaired, and no glue is to be had handily, insert the stick, then fill the rest of the cavity with pulverized rosin, then heat the screw sufficient to melt the rosin as it is driven in. Chairs, tables, lounges, etc., are continually getting out of order in every house; and the time to repair the break is when first noticed. If neglected, the matter grows still worse, and finally results in the laying by of the article of furniture as worthless. Where screws are driven into wood for temporary purposes, they can be removed much easier by dipping them in oil before inserting. When buying screws, notice what you are getting, for there are poor as well as good kinds. See that the heads are sound and well cut; that there are no flaws in the body or thread part, and that they have good gimlet points. A screw of one make will drive into oak as easy as others into pine, and endure having twice the force brought against it.—*Ohio Farmer.*

CHINESE literature has met with a serious loss in the destruction by fire of a wing of the Emperor of China's palace, which contained stores of books and blocks for book printing.

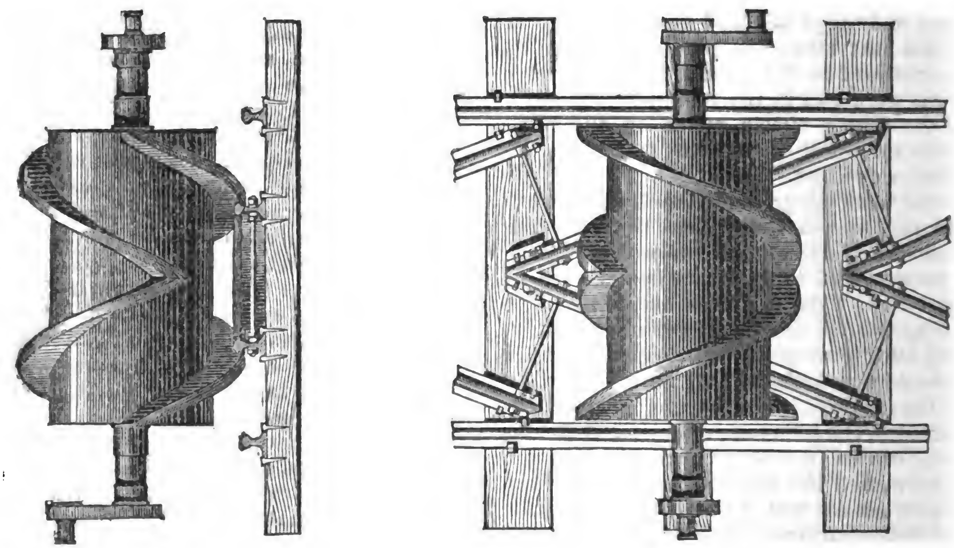
THE WETLI SYSTEM OF LOCOMOTION FOR STEEP INCLINES.

From "The Practical Mechanic's Journal."

The penetration of the great Alpine chains by railways, already, we may say, accomplished over the Brenner and Mont Cenis, and now not far from being commenced over the St. Gothard, and to be followed no doubt, within the next 20 years, by lines over many other great mountain chains in Europe and Asia, has called for several new projects for meeting the difficulties which exist in giving sufficient adhesion with the ordinary locomotion.

Mr. Fell's, originally M. Vignolles's, mid-rail system, as actually at work over Mont Cenis, is one of these; the highly ingenious Italian wire-rope traction system, as exhibited in the Parc at Paris in 1869, is another. The atmospheric railway system was anterior to all. Mr. Fairlie proposes, on acknowledged principles and without changing anything essential to ordinary locomotive working, to effect this removal of difficulty by merely increasing the number of points of rolling adhesion and diffusing the whole load upon these equally; and there have been several other schemes which we need not refer to in particular, as being more or less chimerical.

We have now a new proposal, for we



think, whatever else may be said of this system of M. Wetli's, that it is new, in application at least. Our engraved figure will at a glance enable our mechanical readers to comprehend in what mainly it consists. Dr. Hooke's stepped spur-wheels or spiral gear—which is well enough known not to need our referring to it further than to say it consists in engaging wheels whose teeth have faces inclined to the axes of rotation, and may be regarded in fact as portions of the threads of a screw being one wheel, and of an endless nut being the other, and which threads necessarily only touch at one point at any movement, these points of contact passing over the whole length of each tooth successively as one tooth passes after the other; this system of gear constitutes the basis of the Wetli system. In an ordinary pair of Hooke's spiral spur-wheels the teeth slope only in one direction, *i. e.*, looked at on edge the teeth of either wheel at the axis level slope off lowest at the left-hand or *vice versa*. It results from this that the mutual pressure of the teeth of the two wheels produces a laterally resolved pair of forces tending to cause the wheels to slip asunder sideways or along their axes, were they free to do so, in opposite directions. Were two pairs of such spiral-toothed spur-wheels set side by

side, however, and keyed on their parallel axes with the slopes of the teeth of one pair *reverse* to those of the other, these resolved forces being mutually neutralized, there would be no longer any resultant in the line of the axis of either.

Now, if in place of one of the pairs of such spur-wheels, we substitute a spiral-toothed *rack*, that is to say, a wheel whose radius is infinite, we have complete the elements of the Wetli system. The rack is the railway, between the rails of which are laid two sets of diagonal bars at intervals, pointing towards each other and meeting in the centre of the gauge of way. These are the spiral teeth of the rack. The driving-wheel of the locomotive to be employed consists of a cylindrical drum of the same diameter nearly, and keyed upon the same axis with the main bearing wheels of the locomotive, or upon more than one such axis. Upon the exterior of this drum are fixed projecting spirals which take into or engage with the spiral teeth or diagonal rails of the way, nipping together at two opposite points abreast of each other at the same time, and these bearing points rolling successively from the outer part next the rails to the centre part or middle of the way, and as they roll, dragging on the engine and train as though upon one of the ancient Blenkinsop tooth-and-rack colliery engines and railways of the north of England of pre-Stephensonian days, but always without any rattle or blows or back-lash.

Before one double spiral pair of teeth have lost their hold, a second pair as before have got engaged, and so the gear between engine and railway is constant. That locomotion, and very steep locomotion, *can* be thus effected does not admit of doubt; and were it possible to insure such accuracy and exactitude as to gauge of way, position, and firmness of holding down to the sleepers, on the part of the diagonal bars or spirals between the rails, and sufficiently perfect uniformity of level always between the rails and these spirals —in a word, if we could insure such a state of things as we should have were the rails and spirals between them all of cast-steel and in one piece, and bedded and secured down upon solid rock, then we should add that this method had been brought into a practicable state.

Unfortunately, however, such are not the conditions of any railway which are possible, for however short a time; and they are such as the contingencies of traffic, of wear and tear, of weather, and of the accidents of Alpine climates, oblige the widest divergence from, however well a line be designed, or however well its maintenance be attended to. Rails must be secured to sleepers of some sort; these must sit on ballast; more or less elasticity and yield of the way must be provided for. The rails, therefore, constantly alter their level and their position in all three possible directions more or less, and more or less carry with them the sleepers which at once sustain them and hold them to the earth. These spiral bars or diagonal mid-rails must be secured to the sleepers, and so must partake of their mobility. Furthermore, the ballast itself is subject to rain and frost, weather and floods, and often compels movement in the sleepers fixed in it, or goes away altogether, and leaves these partially unsupported.

All these, we fear, inevitable irregularities seem to present difficulties in securing the effective, constant, and certain hold between these spiral teeth in the engine and the rail spirals that appear as yet without a solution.

We do *not* say they are *impossible* to be met, and met within those limits of expense, and of what we may call flexibility in the system of the way, that are indispensable to enable it to be passed round curves, to sustain drought and floods of rain, and so forth, which must be paramount provisions in every permanent-way system.

And we can easily see that some of the doubts and difficulties which first present themselves to the practical consideration, admit of solution. Thus it must occur to anyone that the effect of any slippage upon a steep ramp, between the driving spirals and the fixed rail spirals, must prove disastrous, inasmuch as those spirals which should come into collision again directly after such slippage or loss of bite, would strike each other with the conjoint velocity of the slip backwards of the engine and train, and that of rotation of the driving drum spirals, the engine, too, for the moment, running away nearly as if in free air. But were there two or more driving drums on the Fairlie plan, in some degree under the same or under two closely following

engines, so as to occupy in all several yards in length of the way, such a general slippage would be almost impossible, one or more of the driving drums being always in hold. The *riding* of one spiral upon another by any misfortune would be a more formidable accident, but it is not hard to see that that also may be met.

The inventor of this system, M. Wetli, is an engineer, we believe, engaged in practice in Switzerland; and his system there has seemed sufficiently important and feasible that the High Federal Council (analogous to our Upper House of Parliament) of the Confederation has demanded a report upon it from the Council of the Polytechnic Federal School. That report, signed on behalf of the reporters by M. Charles Pestalozzi, dated at Zurich in August last, was presented to the Swiss Parliament, and has since been published at Berne, along with a very able report by Professor Culmann of Zurich, and a very clear description of the principles engaged has been produced by Professor Gustave Zeuner, whose reputation is well established even in Great Britain, and Professor Georges Veith, also of Zurich.

All these authorities admit the possibility, and are disposed to presume on the feasibility in practical working of the system, the conceivable difficulties and objections presented by which they have very fully discussed.

It is one of those cases, however, to which we may apply the German proverb, "Probiren geht über studiren," or, as they say in the potteries, "Nothing beats a trial." Experiment, and that upon a large and costly scale, and after careful design of the best thought details of plan, can alone really decide whether this would or would not prove a desirable method of railway climbing of Alpine passes.

As regards cost, the official reporters estimate the Wetli way, as designed by the inventor for the double line of St. Gothard, at 767,000 francs per kilometre, or only 15,000 per kilometre greater than that of the same way on the ordinary system of locomotive.

The difference looks small, and the cost may be underrated, but it is to be weighed against that of a tunnel through St. Gothard like that through Mont Cenis, then, as respects first cost, there can be no room for doubt as to which is the cheaper. That, however, is far from being the whole question; maintenance, durability, and cost for traction per ton per mile on the assumed traffic, for a prolonged period, say for twenty years, have to be taken into account if the relative cheapness as methods of transport be really to be compared; and these must present many items in favor of the tunnel, or rather many tunnels, though charged with the interest of a no doubt enormous capital expended in its or their production.

On the other hand, the longest way between two points connected by rail must always be the most costly in outlay and in working, and the moderate gradients *must* always be the longest way.

One form of rack or toothed rail, and different from this of M. Wetli, viz., that of M. Riggenbach, is about forthwith being tried upon a small line of Swiss railway, which, when completed, will probably be one of the most curious, as it undoubtedly will be one of the most interesting, in the world. It has been decided to connect Lucerne with the summit of the Rigi Alp by a line of railway, which, allowing for irregularities in the contour of the ground, is to wind up round the mountain like the fusee of a watch.

The plan of Herr Rach proposed for this does not seem to us nearly as feasible as this of M. Wetli.

Upon the latter plan Signor Agudio, who has given much attention to railway construction of steep ramps, has proposed some modifications, which, however, do not appear to us important as improvements.

In conclusion, this Wetli plan is certainly well worthy of being tried, and there are a good many spots, even in our own country, where the experiment must be made, and, if successful, with permanent advantage to the projectors.

Madrid Waterworks.—Although that fine country, Spain, has long been in a state of chronic disorder, and for the last 16 months in the agonies of an interregnum, more than one great work, besides the railways, has been accomplished within the last few years, the principal one being the grand reservoir and aqueduct for the supply of Madrid with good water. The total cost was £2,300,000, including additional work on the principal weir, founded on limestone rock, through which great leakage took place.

ARABIAN DESIGN AND ART.

From "The Builder."

In the course of discussion in a paper by Mr. J. D. Crace, Sir M. D. Wyatt said: I need scarcely remind you that the germs of the Arabian technical and ornamental arts are to be found in those of the Byzantine empire, to which they had for the most part descended from the decaying Roman empire. If there is anything in Mr. Crace's admirable paper to which any one could take exception—a cavilling in which, indeed, it would be almost wrong to indulge—it might possibly be that the speaker's notice of the history of Arabian art scarcely sufficiently carried us back to the stock upon which it was engrafted. The victorious armies of the Prophet and his immediate followers speedily carried Islamism over vast tracts of country, upon many of which technical and decorative arts had long been cultivated with signal success. Hence the peculiar conventional character with which the Arabians so early stamped the eclecticism arising from the junction effected at Byzantium, in Asia Minor, Africa, and Spain, between the Orientalism of Persian and Indian arts (as they existed before the Hegira) and the classical type traditional amongst artists and workmen trained on the system of Imperial Rome. I have myself had occasion to point out in this room the intimate connection which existed between the Persians and Justinian, and its influence on Byzantine art. The peace which was concluded between Justinian and Chosroes Nushirvan was one that was "to last forever," according to the terms of the treaty; and Persian architects were largely employed by Justinian. Thus we see in the details of St. Sophia an evident departure from both the technicalities and the principles which characterized the old Roman works, and a certain marked anticipation of some of those changes of form and predilection for inlay and surface decoration in structure which were afterwards manifested to a great extent in the works of the Arabs. The second aspect under which this subject is interesting to us as practical professional men—students, at least, if not masters, of the handicrafts we control—is the technical basis of this style. This it was which made it vigorous from its earliest date, and has imparted to it the perfection of execution which always characterized it. From first to last it has exhibited the skilful workman compelled to do his best unflinchingly, and obviously to please a master, jealous of good works, who would put up with no half-hearted service. Every artisan, whatever may have been his specialty, engaged on the great works described by Mr. Crace, was a master of his craft, who carried out his work in subservience to the methods and best traditions of his trade, keeping closely to every characteristic of design and workmanship which the materials he used demanded, and which the tools and processes at his command best enabled him to execute. From his intelligence as an operative, his enlightened ideas as a designer, and the perfection which the revival by the Arabian mathematicians speedily effected of the study of geometrical form (which had been carried so far by the ancient Greeks), enabled him to bring to bear upon his special branch of industry, he was speedily in a situation to originate new features in his business, and to make the old ones far more beautiful than they had previously been. Thus in carpentry and joinery, from the very dawn of technical Arabian art, we may observe a clear recognition of the best mode of combining and contrasting, both in form and color, all the various woods which appeared to be at command. Not only was this the case with woods, but we find the same intelligent use with other materials in all the architectural works of the Mohammedans. I differ a little from my friend, Mr. Owen Jones, in what he has remarked with regard to the place and period in which Arabian architecture was most highly perfected. No doubt it is to be recognized in the earlier portions of the Alhambra, as having attained a thoroughly concreted system, in which, as in perfect Grecian architecture, every part had its definite form and dimension allotted to it, without confusion, and with such true and absolutely mathematical design and setting out as to preclude the possibility of

the concurrence of a pattern geometrically inaccurate, or one which does not complete itself in all its parts and repetitions. We find this development of completeness in the Alhambra in its extremest complication, but we find it no less complete, though in a simpler form, in the earlier works at Cairo, such as those of the Mosque Tooloun, and in the Meschita at Cordova. At the same time, we find it associated with better ideas of structure in the technical simplicity of the primitive Arabian system, and in the clear expression of function in every architectural member. Certainly in the Alhambra, with which I am myself better acquainted than with the monuments of the Khalifate, we find the overlaying of the stucco and colored decoration has to a certain extent hidden the structure itself; and beautiful as this overlaying certainly is, and perfectly as it has been made to harmonize with all of structure which is allowed to remain visible, it generally, to my eye at least, obscures too much. In earlier works, both of the Arabs and Moors, a principle of simple masonic construction is always indicated, and the stone is never overlaid by the plaster, nor is the eye misled by the inlays into confusion as to the system of jointing. In thus dwelling upon the beauty of Arabian masonry, I would not be understood for a moment as depreciating the plaster-work (as such) of the whole range of Mohammedan design, from the days of Ebn Tooloun to those of Boabdil el Chico, since during all the many centuries intervening between the reigns of those sovereigns we find, in stucco, admirable hand-worked patterns, executed with a precision and force at least equal to those we meet with in the works of ancient Rome itself. There is one more aspect under which this subject is interesting to us. In the present day there exists on all hands great desire for novelty in the main features of design, as well as in the decoration of buildings. I believe that legitimate novelty in this direction is not to be obtained by a mixing up of styles, or by confusing them together; it is rather to be found in the development in new directions of technical arts, which, if they have not already done so, may in the future be made to minister to the operations of building and decorating. It was by "developing" in this direction that the Arabians found strength, novelty, and completeness of style; and as they did, so may we do. When I look at their tiles, I see one direction at least in which we have been for some time so following on Oriental lead, and I note in them a very legitimate and excellent form of decoration, calculated, I think, to effect a great change in the aspect both of our exterior and interior architecture. I know it has, to some extent, done so already, and I believe it will do so yet more. I see also in this variety of Arabian wood-work, involving an apparently very intricate, though really simple, combination of different patterns, nothing which any skilled workman with the least desire to do what has been so well done, and what seems so thoroughly congenial with a just idea of good joiner's work, would not be able to do perfectly in this country at the present day. When one looks at the rude materials and processes by which elaborate and beautiful works were carried out in almost every technical art by the Arabians, it is difficult to imagine why the same good work should not be designed by us architects, and wrought by our artificers, who should learn to take a pride in their calling, and be honored in proportion to their merit in it, as the Arabian workmen were. All that is wanting is, that the same simple taste, good judgment, and technical energy should be bestowed upon our designs and upon our works. Men are yet to be found in India and Persia, in Cairo, and even in Spain, who, in some degree, retain the theory and practice of the most ancient Arabian tradition. I myself saw in Granada, only a few months ago, a man working with a lathe of the kind described by Mr. Crace; the only difference was, that the lathe I saw consisted of a long iron bar, with "gudgeons" sliding on it, and capable of being fixed by screws at any distance apart. Between these gudgeons a piece of wood was so held as to be capable of gyration, with the least possible amount of friction. The workman sat down with this in front of him, and kept it working with a bow, similar to that constantly used by Indian turners, which twirled the wood round rapidly on the iron gudgeons. This he did with his left hand, while with the right hand he steadied himself, changed his cutting tools, and measured from

time to time the gauge of the work he was doing. For what right hands usually do with ordinary lathes, he substituted his right foot, which exhibited an elongated great toe just like a thumb, and a metatarsal development such as I never saw before. He held the chisel tightly between the great and second toe, and seemed to use his foot just as easily as we ordinarily use our hands. It was curious to find at Granada such a retention of the simple machinery and method by which it is probable that the Moors executed the bulk of their larger ornamentations in wood, dependent upon the lathe for the fashioning of their leading forms. I trust I may be permitted to allude to one more point before I sit down; and that is, the opportunity for surface decoration which was afforded by the large wall surfaces in which the Orientals have always delighted, and by their simple arch soffits and vaults, rarely cut up by moulded work or chamferings. I cannot help thinking that these remarkable "reversible" patterns which we see here, and the effect of which is invariably excellent, were probably originally due to the desire to economize labor and cost by making one piece of material serve, by counterchanging and interchanging the parts into which it was cut, to produce patterns in different colored materials without the waste of any portion of material. At the same time I cannot but consider that, speaking theoretically, patterns so formed appear to be in strict compliance with that which was, and should be always felt to be, a bounden duty to carry out in colored decoration, viz., equalization of superficial areas of contrasting colors in the design of patterns intended to convey a sense of tranquil beauty. The principle was no less important when the contrast was intended to be effected by *chiaroscuro* only or by variety of materials, than it was when the effect was intended to be produced by contrasting colors. Equalization was demanded of the light and dark shades. It is such regular balance which keeps ornamentation quiet, and which gives to it its dominant aspect of repose. Balance, it should always be remembered, is just as essential to repose in decoration, as equilibrum is to security, and its appearance to a sense of security, in structure.

A NEW GUNPOWDER.

From "The Scientific Journal."

Among the many practical applications of phenic or carbolic acid, not the least important is its use in the preparation of picric acid, a substance which, in combination with potash and other bases, promises to be of great value to the arts. Although readily produced from other substances, carbonic acid appears to be the most desirable source of supply, and only requires to be treated with concentrated nitric acid. A combination takes place with a hissing noise, and results in the formation of picric acid, in long lamellar crystals of a beautiful lustrous yellow color, and of an intensely bitter taste. Already used extensively in the preparation of dyes, it is, as an explosive, of peculiarly valuable properties, that we now call the attention of our readers to it, as when heated suddenly to the proper degree, it decomposes with explosion, and this peculiarity is increased when combined with an alkaline base. The picrate of potash is the most important in this respect, and has lately been the subject of extended experiment on the part of an eminent French chemist. This is a salt of a beautiful golden yellow color, crystallizing in prismatic needles, and while insoluble in alcohol and nearly so in cold water, dissolves readily in fourteen parts of boiling water. Heated carefully, it acquires an orange red color at 572 deg. Fahr., which it loses on cooling; heated rapidly to 620 deg. Fahr., or brought in contact with red hot bodies, it explodes violently. It is most readily prepared by the double decomposition of a soluble picrate of soda, magnesia or lime, and a salt of potash, or by the direct action of picric acid upon the carbonate of potassa. The explosion of the picrate gives rise to an immense volume of gaseous matter, as nitrogen, carbonic, and hydrogen and oxygen, and the only solid residuum is a little carbon and carbonate of potassa.

The smoke produced is very light and easily dissipated, and the gaseous products are totally destitute of the corrosive and poisonous action of those of gunpowder, with their thick, heavy, stifling smoke. Nearly insoluble in cold water, there is no absorption of moisture from the atmosphere to deteriorate its quality or destroy its utility, as with gunpowder, so that it may be used in the dampest mines, where also the almost total absence of smoke and of noxious products after explosion, is a great recommendation.

Two varieties of the picrate powder are now manufactured, one for blasting, the other for fire arms; each made of various grades of strength and adapted for special applications. For the first purpose, nitrate of potash is used with the picrate; for the second, an additional ingredient, charcoal, is employed, the latter being added to diminish the rapidity of the combustion and increase the projectile force. This can be regulated so as to be greater or less than that of gunpowder, while the blasting power is much greater than that of the latter substance.

Our space will not permit us to go into mere detail respecting this new powder, which is so easily made and kept unchanged, and can be made of any desired degree of strength, and in its explosion yields no deleterious or corrosive gases, blinding smoke, or acrid and troublesome residuum. It is nearly as cheap, and less easily ignited by carelessness or accident, than gunpowder. Of much greater blasting power, and quite equal to nitroglycerine in this respect, it seems destined to play a very important part in mining operations, while the comparative absence of solid deposit renders its use in gunnery highly advantageous. The color is a brilliant yellow, and thus it is easily distinguished among other substances. It is also of varied application in pyrotechnics.

In conclusion, we may state that the picrate powder is the subject of extensive and secret experiment with the French Government, which will probably use it before long as a substitute for the old-fashioned black gunpowder, in its military and naval service.

THE BOUTET BRIDGE.

From "Engineering."

From the first effort of M. Charles Boutet to make English converts to his proposed system (?) of building bridges in impossible spans, we have not hesitated to say in plain words what we thought of the invention, and we have from time to time given out our opinion with so much of force that we believe we have effectually counteracted all the endeavors of the projectors of the so-called Channel Bridge Scheme to gain shareholders in this country. Whether this wonderful association still exists here, we know not; but this is certain, that M. Boutet cannot with any chance of success bring his plans again before the public, although very possibly the favorable notice his scheme received lately at the Society of Engineers may gladden him with delusive hopes.

So far, so good; we may consider ourselves done with Boutet, but, as our readers know, from time to time the French papers have been not unfrequently conspicuous for flourishing descriptions of Boutet and his bridge. Now, it was a picture of the Emperor inspecting the models at the Depot des Marbres, now an announcement of the construction of a Boutet bridge at St. Malo, now a promise of the almost immediate commencement of the great Channel bridge itself. Some of these paragraphs translated may have been seen from time to time in English papers, but beyond this we know nothing, for the narrow strip of troubled water which isolates us from the Continent serves also as a great non-conductor of intelligence, and cuts us off from many details of information, which the mere distance does not account for.

A minute report, however, of the progress of the great international bridge scheme lies before us, the joint production of MM. Hauvel and Lockert, two engineers of the Ponts et Chaussées. We believe that this report will shortly be published in the French scientific press, and it will doubtless be received with much favor. "You ask," say MM. Hauvel and Lockert, "intelligence of M. Ch. Boutet,

engineer: he is always in Paris, always devoted to his vast project of the Channel bridge, always to be found at the Depot des Marbres. What do people think of him? Truly, those who can think, don't think of him at all. But he works hard. Each day he explains with affability to every visitor, possibly a future shareholder, those principles, not less simple than ingenious, upon which the bridge is constructed; he produces immense plans, medium-sized plans, little plans; he handles lengths of wire cables of all dimensions, he expatiates on the weight of the structure, its cost, its future prospects; and, inspired by the proximity of an Imperial bust, which imparts an august influence to his bureau, M. Boutet inscribes another convert's name in the subscription book; the day's work is done, and the great scheme is furthered by so much. What scheme? The Channel Bridge, doubtless, with its span of 1,000 metres. It was Marshal Vaillant, who, taking an early interest in this project, accorded to the inventor a place on the ground of the Gardes Meubles, at the Depot des Marbres. So one great difficulty was removed, and the affair became sheltered as it were under the shadow of Government. Then the needful funds obtained, an engineer (!) and staff of draughtsmen commenced their labors, the latter operating on the largest sheets of paper procurable, the former working out a mathematical theory to correspond." This theory, the only so-called scientific production in connection with the affair, was published in the "Annales du Génie Industriel" of Feb., 1869. A wonderful ignorance characterizes this work. The question is thus stated to prove that a span of the Boutet bridge can be constructed with an opening of 1,000 metres, of the form and dimensions figured in the drawings: "The span has the form of an arch; the strongest section is required at the abutment; the springing is therefore the only part of the structure we need investigate, and prove correct, for the rest of the span will always come right, provided we give the arch a parabolic form." This is still better: "Let us seek, now, the section at the springing; nothing is more simple; apply the formula." Fortunate formula, to be so accommodating. But in the place of applying a formula relating to an arch, one is used which is applicable only to straight girders. Add to this that the weight of the structure is thrown out of the calculation, and an unique result is obtained, which bears out the assertion of M. Boutet: "We are thirty-six times stronger than we need be." But despite all these egregious blunders, there is little to be wondered at that not a few speculators of hazy notions have ventured more or less in this wonderful bridge scheme. But so much of popularity as M. Boutet has obtained in Paris is due principally to the indifference of French engineers, who deem the whole business too unworthy of their notice. Not that the inventor would be daunted by criticism, but silence is construed into an acknowledgment of merit. On one occasion, indeed, it is said that four young engineers of the Ponts et Chaussées had the audacity to laugh outright in the presence of the presiding genius, saying: "If you will undertake to build a bridge upon this remarkable and unique system 100 metres in length, and which will bear its own weight, we will pay for it." Whereupon M. Boutet goes forth straightway, grave, and full of serious purpose, saying to all around, "Messieurs, the engineers of the Government have instructed me to build forthwith a bridge upon my system 100 metres long."

On the 8th of June last, Fortune visited M. Boutet, embodied in the Emperor, accompanied by General Fané, Marshal Vaillant, and several members of the Academy. But this was hardly, perhaps, the crowning glory, though, possibly, its results were highly gratifying. It was at Vervius and St. Malo that this truly remarkable man reached the climax of his greatness. Deponent saith not how or why he became fêted and a hero; nor whether the musicians, firemen, and other elements of a provincial demonstration, celebrated him on similar terms to those of the serenaders of Artemus Ward. Nor is it clear how it came to pass that a Prince of the Blood, a Grandee of Spain, in short, the Duke of Saldana, met him, embraced him, and said of him, "Behold one of the greatest men of the century!" But these things happened, and we give M. Boutet his due. And, after all, M. Boutet is a remarkable man. We have ere this glanced at his antecedents, let us now record one of his previous works. On

the 6th of July, 1858, he obtained a patent entitled, "Hydraulic Motors, applicable to all cases in which power is required." This contrivance is, in fact, a perpetual motion, nothing less. That is something, but not enough for M. Ch. Boutet, as he states in his specification: "This last system (he patents three) is superior to the two first, because it is evidently more simple, and gives, with equal means, double the power." So that this ingenious creature has positively devised three systems of perpetual motion, the last of which is twice as perpetual as the two first.

After this, we need be surprised at nothing that M. Boutet can do; 1,000 metres bridge spans are a mere trifle; and equally it is little to be wondered at that the subscriptions for the scheme amount, it is said, to some 200,000 francs. All we can say is, that we have reason to be glad that the sum has been paid in francs, and not in pounds sterling; that it has come from French purses, and not out of English pockets.

HOISTING STONE IN QUARRIES.

From "The Mechanics' Magazine."

The dangers that attend the men who go down to the sea in ships and transact their business in great waters are scarcely greater than those which await the toilers who descend into the bosom of the earth to win the mineral treasures to which this country in particular owes so much of her greatness. Whether it be in the mine or in the quarry, death or disablement are there awaiting the unfortunates who may happen to fall a prey to them. In the case of mines, we hear too frequently of fatal catastrophes, but, strangely enough, the disasters which occur in quarries rarely find their way into the columns of the press, perhaps because each disaster is, in itself, too insignificant as compared with the wholesale slaughter of a colliery explosion. We have good reason, however, to know that the annual loss of life and limb in quarrying operations is by no means trivial; unfortunately, too, a large proportion of these quarry accidents are more or less preventable by improvements in the hoisting machinery and appliances used to raise the stone when hewn, to the surface of the ground. The present arrangements for lifting may not be familiar to some of our readers, so we will briefly describe them.

A large quarry in full work presents a considerable area of operations, and, as a rule, there is but one engine to hoist the material; this is usually placed on the edge of the quarry at the end of the tramway along which the stone is taken when raised. The engine is generally on the surface ground, but a sort of step or recess is cut close alongside it, and whose level is about ten feet lower; the tramway is brought to the edge of the quarry along this step so that the lorries for the stone are beneath the engine level. In a large and deep quarry it is evident that nothing in the way of a jib crane can be made available, and a gantry and traveller would be too expensive even did such an apparatus give sufficient scope to reach all the area in work. Instead, therefore, of either, the following plan is adopted. A large chain is stretched from the engine-house across quite to the other end of the quarry and there secured, but not permanently so, this end being shifted from time to time as the position of the stone being hewn requires. On this chain a sort of carriage runs; it is something like an iron block, with two sheaves set side by side in the direction of their diameters, not of their axis. They are wide and deep enough in the grooves of their edges to run on the chain as on a rail. This block carries a real block, or what answers to one, suspended under but close to the chain; through this the rope or chain for lifting is passed.

It will be evident that the hoisting rope has a merely vertical action, but the block, or "horse" as it is technically called, gives both a vertical and horizontal motion, as the chain is most generally on a considerable inclination.

The *modus operandi* is as follows: When a certain stone is to be raised the chain is moved over it and the quarry end made fast. The "horse" is run along the chain till "plumb" over the stone. A "toggle" or pin is secured in a link be-

hind it to prevent it moving down the slope of the chain and the hoisting rope is paid out and the stone hooked on, which is raised till the lifting hook reaches the "horse," when it is secured to it. The engine then draws the "horse" along the chain till the stone is fairly brought out of the quarry, and over the step already described, as well as over a lorry placed there in readiness. A "toggle" is put into a link of the chain to prevent the "horse" going back, the stone is lowered into the lorry, and the operation is complete.

Any person with the most moderate knowledge of engineering must perceive that, however cheap and convenient this arrangement may be, it is fraught with danger to those working or passing beneath the chain; the very best chains carefully tested are uncertain affairs even when subjected to a simple statical strain, and the strain of the main, or, as we may term it, "gantry" chain in a quarry is not a purely statical one by any means, as the "horse" when it begins to move "jumps" over the links sufficiently to cause a considerable "jar," which, as a matter of course, is constantly breaking the chain, or if the hauling chain or rope from the engine happen to break, the "horse" runs violently down the incline of the chain and the latter, already perhaps loaded nearly to its limit of strength, succumbs to the vibration, and the stone and ends of the fractured chain in all probability fall on some luckless workman beneath.

We have good reason to know that appalling accidents from this cause are common, a fact scarcely to be wondered at seeing that there is no adequate inspection of the arrangements of quarries, and the chains and whole apparatus are of inferior quality in too many instances.

We will proceed to sketch the outlines of an arrangement which we consider to present some advantages over that already described. The chain should be abolished altogether, and either a steel wire rope or a rail substituted. The rope would be little, if at all, more expensive than a chain, while it would be infinitely more trustworthy; less power, too, would suffice to raise the loads, as the wheels of the "horse" would have a comparatively smooth and uniform surface over which to travel. We believe a rail might be arranged made of round iron jointed much as a gas pipe is, the ends of the joint sockets being rounded on their outer edges to give freer passage to the wheels of the "horse." Instead of the "toggle" used with the chain to prevent retrograde motion, a "clip" should be put on the rail (or rope) made of two pieces of iron hinged at one end and with a coach screw at the other, each half being nearly semicircular in the centre; this part would embrace the rail, and if screwed up tightly would prevent backward motion, or at the worst would act as a brake if the strain were too much for it. As to the catenary formed by a chain or rope the rail would equally well assume that curve, as if of good iron its diameter need not exceed by more than one-half that of the round iron in the chain links, and being without a weld would be reliable to an extent such as the very best chain can never equal. This round iron rail arrangement would be far cheaper, too, than the chain.

It is a discredit to us as a nation at the head of civilization and engineering science that such rude appliances as that described in the beginning of this article should be retained to the exclusion of better ones.

As projects of importance in Northern Germany may be mentioned: 1. The Great Canal from the North Sea, near the mouth of the Elbe, to the port of Kiel, on the Baltic. The plans are fully prepared, and the works estimated at about five millions of pounds sterling. 2. A new Port of Commerce and Refuge on the Western Coast of Sleswig, where the island of Rom is to be connected by an embankment of about 3 miles long, with the coast, the port on the island being thus brought into communication with the continental railway system. This harbor is expected to be the most accessible port on the German coast under all circumstances of wind and weather. The works are estimated at about £750,000 sterling.

A Trinity steamer has taken out men and stores from Penzance for the building of a new light-house near Ceylon, under the superintendence of Mr. Douglas, who has lately completed the Wolf Rock Lighthouse.

EFFECT OF SUDDEN LOADS ON CAST-IRON.

From the "Building News."

Brittle substances are usually defined by physicists as those in which the force of cohesion is comparatively weak. Their particles, or component atoms, are therefore held somewhat loosely together, and when exposed to strains of certain descriptions, possess little or no resistance. It will probably here be observed that many brittle substances are endowed with very considerable powers of resistance to a crushing force, although they display but very feeble tensile strength. This is no doubt true. Cast-iron, for instance, will stand a direct crushing force of 50 tons to the square inch, while its tensile strength is only 8 tons to the square inch. But the real strength of the material is only to be depended upon when the crushing force is applied in a particular manner. It is not so much a question of the amount of the force, as of the manner in which its action is exerted. When it is stated that cast-iron will bear a crushing or compressive strain of 50 tons per square inch, it is always presumed that the strain is applied to the material in a similar mode to that which prevailed at the experiments which fixed that constant. Whenever the weight of 50 tons, or other crushing weight, is imposed upon a square inch of cast-iron, it is supposed to be by gradual and almost imperceptible increments, commencing with a very small weight, and terminating with that which ultimately determines the fracture of the specimen under experiment. If, on the contrary, the weight be applied suddenly and violently, the material will yield to one very much less in amount. It is this liability to give way under a sudden strain that has rendered engineers so very cautious in employing the material in any situation where it might, perhaps, inadvertently be exposed to its influence. By an excess of caution, cast-iron is frequently, from the same cause, debarred from being applied to numerous useful purposes to which it is perfectly well suited, and in which it might be adopted without the slightest fear of disastrous or unforeseen consequences. It is, no doubt, advisable, especially for young members of the profession, to be "on the safe side," as it is termed; but nevertheless, while adhering to the example of precedence, and the result of experience, one must not be afraid to employ a constructive material simply because its employment has been in some instances attended by failure; however, it should not be forgotten that the majority of these failures occurred in the early days of railways, and were due more to the incompetency and rash judgment of the designers of the structures than to any real defect in the material.

At present it may be safely presumed that our knowledge of the nature, properties, and capabilities of cast-iron under strain, is more complete than it previously was, and it might therefore be concluded that bridges and other structures of that material were not likely in future to be subject to such contingencies. No doubt such accidents are rare, but that they still happen is demonstrated most absolutely by the occurrence that took place recently at the bridge of Elkantara, in Algeria. A description of this bridge will be *apropos* to our present article, and very instructive to those who may have the designing of works of the same or similar character. In the first place, let us briefly relate the accident. A roller of 5 tons in weight was traversing the bridge backwards and forwards for the purpose of crushing the metalling and bringing it to a smooth surface. On a sudden the roadway gave way. The horses attached to the roller were able to maintain it for a few minutes in a suspended condition, while the driver cut the traces, when it disappeared into the gulf beneath with equal noise and rapidity. The ravine across which the bridge of Elkantara is thrown is nearly 400 ft. in depth, so that both driver and horses had a very narrow escape from being dashed to pieces. The span of the bridge, which is wholly of cast-iron, is 184 ft., and the clear width between parapets, 33 ft. There is not the slightest difficulty, in the present instance, in arriving at the cause of the accident. It was the breaking of one of the cast-iron plates constituting the roadway, under the heavy rolling load brought upon it. There are altogether five arched ribs composing the framework or main girders of the bridge, two of which are the face or outside ribs, and the oth-

ers the interior or intermediate ones. These latter are spaced about 9 ft. 9 in. apart, and the whole are braced together by cross girders and trussing, also of cast-iron. The transverse girders are of a plain T section. Upon the intermediate arched ribs are placed the cast-iron road plates, their span being nearly equal to the distance between the centres of those ribs, which is evidently a long span for cast-iron plates in the situation under description. The plates are slightly cambered, and their average thickness is 0.8 in. That of the metalling is about 10½ in. The framework of the structure was not in any degree affected by the accident.

A glance at the construction of the bridge at once points out that the contingency was, in the main, due to an attempt at false economy. The design clearly was to dispense with the usual transverse road beams, and make the cast-iron plates do the double duty of acting as road plates and girders at one and the same time. The shape and section of material that will answer perfectly for a road plate pure and simple, where the span does not exceed 3 ft. or 4 ft., is not by any means adapted to situations where the span becomes nearly 10 ft. It is somewhat extraordinary that the French engineers, who, as a rule, calculate the action and effects of strains upon bridges a great deal more precisely than we do, should not have appreciated the exact nature of the case. At the very first sight, a road plate of cast-iron nearly 10 ft. in span is a very unusual piece of construction, and it could not fail to strike one that in that position it would be acted upon by other strains than that of compression. Cast-iron in the shape of a road plate is not adapted to undergo tensile or transverse strain, and even in the best form, namely, that of Mr. Hodgkinson's girder, it is not altogether reliable under a heavy impactive or concussive load. In addition to these theoretical objections, there are also others of a practical nature. When the ratio of the thickness of the plates to their superficial dimensions is considered, it is not an easy task to insure that the casting should be thoroughly, uniformly, and homogeneously manufactured. Any flaw in it, which might, under less trying circumstances, be of no importance, would be fatal to a plate in the situation it was placed in at the bridge of Elkantara. On the score of weight, both cast-iron plates, and the still older practice of using brick arches, to carry the roadway, are objectionable. They are now nearly obsolete with us. Wrought-iron corrugated or buckled plates are the means usually employed by English engineers for supporting the roadway of public bridges, but even in that case their span does not attain to the dimensions of the cast-iron plates which have been just described. The cross girders of a bridge require depth, the road plates, superficies, and it is impossible to combine the two in one without the chance of danger, or incurring an unwarrantable expense.

NARROW GAUGE BRANCH RAILWAYS IN SWEDEN.

From "The American Railway Times."

Since the adoption of the 4 ft. 8½ in. gauge in 1854, as the standard for all main lines, about 400 miles of narrow gauge have been built, both by the State to aid their trunk lines, and by private corporations, and have been operated with very satisfactory results. The 4 ft. 8½ in. gauge has been built at an average cost of $3,250, gold, per mile, and brances of the same gauge, but lighter rails, superstructure and equipment, at an average of $2,300, gold, per mile. The following is a partial abstract from the report of the State Engineer, Major Adelskold, of a narrow gauge road lately built by him, and of others previously built and operated under his charge. He says:—"This short 23 miles length road, between the iron works at Ullinbord and the Maelar seaport, runs through a district in which several large iron-works and saw-mills are situated, and connects that district with the small town of Koping on the Maelar Sea, and the Royal Swedish Main Line. The gauge is 3 ft. 7 in., embankments 13 ft. wide; rails 37 lbs. per yard, secured by splices fastened with four bolts; ties 6½ ft. long, 5 in. thick and 8 in. wide. Grades arranged as follows: from the interior to the sea-

port, in which direction the heaviest traffic is carried, the heaviest grade is 1 in 200, and in the opposite direction 1 in 100; shortest curve 1,000 ft. radius. There are six stations on the line, including the terminal with all the necessary buildings, sidings, turn-tables, switches, etc. The rolling stock was built in Sweden, and consists of 3 locomotives of about 13 tons weight, 9 in. cylinder, 4 wheels coupled, 3 ft. 6 in. diameter; 50 cars for freight, and 6 for passengers. The locomotives have cost about $7,000 in gold. The freight cars are of 6 tons capacity, 16 ft. long, 6½ ft. wide, and have cost $225 each. The passenger cars are arranged for first and second class passengers. The average speed is 16 miles per hour, and 35 miles have been run on several occasions, causing but very slight oscillation of the cars. The cost of this road has been—complete in every regard, including telegraph—$9,700 per mile; and the cost of operating the same for the first year an average of $650 in gold per mile per year. The travel is as yet not fully developed, and by doubling the number of cars, 100,000 passengers and 150,000 tons of freight could be carried without difficulty.

"There are a number of other narrow gauge roads that have met all the requirements made of them, and realized the expectations of their owners in every respect. Two of these are 4 ft. gauge, one 26 and the other 56 miles in length, and are branches of the Swedish main line. Prior to the completion of the first, it was generally believed that the transfer of freight from the branch of the main line would involve considerable outlay and serious loss of time. This objection has, however, proved to be very trifling, as the cost of transferring, when cars are placed beside each other and with suitable arrangements, will not exceed two cents per ton.

"One of my principal doubts was the ability of these light and small engines to keep the road open during winter. The experience of several severe winters, however, has shown that no such fears need be entertained."

He closes as follows:—"In every case where the narrow gauge roads have been built, they have realized every expectation, and I deem it a waste of capital to build broader gauges when a narrower and cheaper will meet all requirements, For as thinly-settled country as this, where the available capital will barely meet the wants of the rapid industrial and agricultural developments, and where cheapness of transportation is of so great importance, the narrower gauge may in many localities be well adapted, if not positively necessary, as they can be easily built and at such cost, that with but a small traffic, they are able, not only to cover the cost of operating them, but pay a good interest on the capital invested."

Wire Rope.—Wire rope, wire cord, and wire clothes lines have been brought into such general use, that articles of this character are no longer a curiosity. One of our exchanges thinks that wire rope and wire cord constitute one of the most decided improvements on the ideas of our grandfathers that are entitled to attention in our enlightened age. The snapping of a sash cord, which leaves a window a heavy burden on all connected with it, has ever been the dread of housekeepers. But the *wire sash cord* at once insures the most nervous against such accidents. For clothes lines, the wire rope must supersede the old hempen arrangement, as it is not only strong but durable. Dumb waiters find in it a reliable way of elevating themselves without fear of disconnection. Pictures in costliest frames may hang most favorably from *silvered* cords that look like shining thread of lightest gossamer. And speaking of gossamer reminds us that wire cloth is manufactured by the same company that make the iron, copper, and silvered sash cord. Even lightning rods are formed of copper wire, so plaited as to be continuous, and therefore not too apt to puzzle the electric fluid with a single joint in its free and easy passage to the earth. The cars of the elevated railway, on Greenwich street, are to be propelled by wire rope belts, a mile in length, extending from the driving wheel of one engine to the large pulley-wheel, half a mile distant, and back to the engine.

A new bridge is to be built at Maldon, Essex, in lieu of one which is 600 years old. Mr. J. S. Cooke, of London, is the architect.

PERFORMANCES OF ENGINES.

By W. H. G. WEST, Engineer, U. S. N.

From the "Journal of the Franklin Institute."

The following is a statement of the performances of a number of engines, collected from different quarters, by engineers of undoubted knowledge and integrity.

Condensing cotton mill and engine at Chester, Pa. Diameter of cylinder 20 in. Stroke 4 ft. Steam cut off about 1 ft. from commencement of stroke. Steam pressure 61 lbs. above atmospheric. Boiler, tubular; locomotive pattern. Coal consumed per horse-power per hour, 2.35 lbs. Duration of trial 60 hours. For one day of the trial the consumption was only 2.057 lbs. per hour, for each horse-power. Chestnut coal gave the best result; and if used during the whole trial, would probably have brought the consumption below 2 lbs.

Non-condensing cotton mill engine. Diameter of cylinder 14 in. Stroke 3 ft. Cut off at about $\frac{1}{3}$ of stroke from commencement. Cylinder boilers. Steam 80 lbs. above atmospheric. Consumption of coal 3 lbs. per horse-power per hour.

Condensing cotton mill engine. Diameter of cylinder 28 in. Stroke 5 ft. Steam pressure 110 lbs. above atmospheric. Cut off varied by regulator. Jacketed cylinder. Tubular boilers. Consumption of coal per horse-power per hour, 1.9 lbs.

Brooklyn Water Works Engine.—Diameter of cylinder, 90 in. Stroke 10 ft. Flue boilers. Consumption of coal per horse-power per hour 3 lbs.

Average performance of a number of stationary engines of and about 20 in. diameter of cylinder, $4\frac{1}{2}$ lbs. of coal per horse-power per hour.

Babcock and Wilcox engine, jacketed, $3\frac{1}{2}$ lbs.

Greene's engine, $3\frac{3}{4}$ lbs.

Corliss engine, non-condensing, $3\frac{1}{2}$ lbs.

Average performance of a number of Cornish engines. Diameter of cylinders 50 in. and upwards; about $3\frac{3}{4}$ lbs. per horse-power per hour.

U. S. S. "Wampanoag," running 18 to $20\frac{1}{2}$ statute miles per hour, after making all allowances for friction of load, etc., and so bringing it to the same condition, in regard to duty, as the Cornish engine, 3.129 lbs. per horse-power per hour.

U. S. S. "Ammonoosuc," running 18 to 20 statute miles per hour, 2.65 lbs. per horse-power per hour.

H. B. M. ship "Constance," *Woolfe* engines, with jacketed cylinders. Steam expanded from 8 to 10 times. Surface condenser. Consumption of coal per horse-power per hour, 2 lbs.

In presenting these proofs of the correctness of a former assertion that many American, and other rotative engines, will compare favorably with the majority of Cornish engines, I do not wish to imply that the above performances are the best obtained from the engines named, but that they are sufficient to prove more than equality. In collecting them, I have been forced to the conclusion, that either the construction of the Cornish engine is not particularly well understood, by the present manufacturers of that interesting machine, or that the old plan of guessing at coal, by the barrow load, led the experimenters of that time astray.

More than 20 years ago the duty was said to have come up to 130,000,000 lbs., lifted one foot high, by the consumption of 112 lbs. of coal; but for May, of this year, the average for eighteen of them was only 50,100,000, and it will be found that this is the general average.

Several writers have distinctly stated, in the "Journal," that the weight of the moving parts is the principal cause of the superiority of this engine, and much importance is attached to the fact of its having a beam; but we know very well that the weights are nearly the same as in old times, and that the weight of the engine beam is exceedingly small, when compared with the weights of rods, balance-beams, etc., which belong to the pumping apparatus, and which must be used with any kind of engine that may be employed. Can prejudice possibly be so strong as to compel any one, even to insinuate, that a slight variation in the strength of parts will make a difference of 80,000,000 lbs. in the duty?

In accepting, as sound, the arguments of the gentlemen who have recently written so warmly and forcibly in favor of these engines, there is nothing left but

to believe that those built in late years are very badly designed. Mr. William West, the designer of the 80 in. at Fowey Consols, would not feel complimented, were he to hear that the success which he sought to achieve by improvement in every detail, was due to clumsy bulkiness.

It is stated in a paper upon steam jacketing that, *practically*, the expansion of metal is nothing, in the Cornish engine cylinder. This is repeating the old story, that theory does not agree with practice, and is an expressed doubt of the ability of such men as Joule, Faraday, Tyndall, Regnault, and others of equally high reputation, to make practical experiments. A beautiful set of experiments is recorded in the November number for 1869, showing the number of vibrations of piano strings in making the different notes; but *practically*, we have every reason to doubt the truth of the statement, because we do not see the strings flap about, like the sails of a ship taking in a gale of wind.

At one end of the Cornish cylinder we have a high pressure, say 60 lbs., the temperature of which is 292.6 deg. Fahr., and at the other end 90 deg.—condenser temperature. Cast-iron expands lineally .0000618 per unit, for each degree of heat added above these temperatures. An 80 in. cylinder will therefore increase its diameter full 0.1 in. The temperature of the piston will be a mean between the other two, and the thickness of the piston being about ten times greater than that of the cylinder, its temperature will not change as rapidly; indeed its diameter will be nearly constant. If it fits well at one end, it must therefore jam, or leak steam at the other. *Practically*, my attention was first drawn to it by one who had observed it in the Fowey Consols 80 in. when an attempt was made to move her, before the steam, passing from the boiler to the jacket, had heated the cylinder all through. After steam had been admitted to the lower end, the engine worked as usual. The difference of temperatures, in that case, was probably 250 deg.; and the difference of diameters almost exactly $\frac{1}{8}$ in. In the same circumstances, the 110 in. cylinder, now being made for the Bethlehem Zinc Mine, Pa., would have a difference of diameter of over $\frac{1}{8}$ in.; and the 144 in. built by Harvey & West, of Hayle Foundry, Cornwall, England, for Holland, would have a difference of diameters of 0.22 in. (nearly $\frac{1}{4}$ in.). Would that be a *practical* leak? The very high steam that some people say is used in Cornish engines, would make the leak greater.

Rankine, in his "Prime Movers," page 568, compares the effects produced with, and without, the steam jacket. The ratio of whole gross work of steam to gross work during admission, will show which does the most work during expansion and will be

$$\frac{\text{mean pressure} \times \text{ratio of expansion}}{\text{initial pressure}} = 3.55$$

for the unjacketed cylinder, and 3.73 for the jacketed cylinder; showing decidedly in favor of the jacket. Condensation in the cylinder, is shown by the ratio

$$\frac{\text{initial pressure}}{\text{mean pressure}} = 5.64 \text{ for unjacketed cylin-}$$

der, and 5.36 for jacketed cylinder; giving a much greater condensation in the unjacketed cylinder.

The same writer for the "Journal," says, that "there is no doubt that a higher degree of expansion is possible with a steam-jacketed cylinder." There lies economy.

I cannot see how admitting more steam, already on the point of condensation, can prevent other steam, with which it is brought into contact, from condensing, as all must expand together.

Steam, in the steam jacket, superheats the expanding steam in the cylinder, by the loss of its own heat, and thereby prevents condensation in the cylinder, to a great extent. It is not supposed to vaporize any that may lie upon the piston, except through the superheated steam in the cylinder.

Two questions arise in regard to steam jacketing: 1st.—Whether it is better to condense steam in the cylinder, thus assisting the condensation by expansion, and to expand the remaining low steam, or to condense steam in the jacket, and get the benefit arising from the use of high steam, together with the increased economy of a high grade of expansion. 2nd.—Whether the heat remaining in the water, into which the steam is converted, should go to the condenser to destroy the vacuum, and the water itself to load the pumps or go back to the boiler, for further use. I should say the latter, in each case. Although it is very right, and proper, for each one to judge for himself, some little

weight should be given to the experience of Watt and other prominent men who have pronounced in favor of the steam jacket.

In the August number of 1869, page 11, we find the following: "A Cornish engine is now running which produces a lower duty than a double acting high pressure fly-wheel engine, used in the same works illustrating *defects in construction.*" This assertion is, without doubt, true, and the writer probably refers to the wonderful thing recently built for Spring Garden or some other Philadelphia Water Works, but which is really not a Cornish engine; or to that singular pair of twins in the West Philadelphia Water Works, that were designed to be Cornish engines, but are not, and which obstinately persisted, for a long time, in pumping water during the latter part of the stroke, only. I am glad to see that some one has the courage to compare them (unfavorably too) with the least economical type of rotative engine.

In the editorial note, September number, 1869, page 159, we find it is stated that 18 Cornish engines averaged a duty of only 50,100,000 lbs., lifted one foot high, by consumption of 112 lbs. of coal, or 447,321 foot lbs. for 1 lb. of coal. A horse-power means 33,000 lbs. lifted one foot high, in a minute, or 1,980,000 lbs., lifted one foot high, in an hour. Dividing this by the number of lbs. of coal consumed per horse-power per hour, we have the number of lbs., lifted 1 foot high, by the consumption of 1 lb. of coal, and proceeding thus with the statistics already given, we have the following results, showing the comparative economy of the different engines:

At 1.9	lbs.	per horse	power,	1.042,105	ft. lbs.	for 1 lb.	of coal.
" 2.	"	"	"	990,000	"	"	"
" 2 65	"	"	"	747,169	"	"	"
" 3.	"	"	"	660,000	"	"	"
" 3.125	"	"	"	632,790	"	"	"
" 4.5	"	"	"	440,000	"	"	"
" 3 75	"	"	"	528,000	"	"	"
" 4.42	"	"	"	447,321	"	"	"

The next to the last is the average of a number of Cornish engines, collected for this paper.

The last is the average of 18, given by the editor.

Fowey Consols 80 in.—exceptional—1.7 lbs. per horse-power per hour, gives 1,160,714, for consumption of 1 lb. of coal, or 130,000,000 for 112 lbs.

Rowan's engine—exceptional—1.12 lbs. per horse-power per hour, gives 1,767,857 for 1 lb. of coal, or nearly 198,000,000 for 112 lbs.

After all that has been written about duty, in the January and August numbers of the "Journal," for 1869, engineers, and other scientific men, will be as much astonished as I am, to find that most Cornish engines, of the present day, are very poor machines, and that several other classes of engines are superior; amongst them the much abused marine engine, which does the same amount of work with about one-half the coal consumed by the Cornish engine.

There is every reason to believe that if all attending circumstances were noticed, and given due consideration, neither Rowan's engine nor the Cornish engine would have shown anything like the duty accredited to them. It is impossible to accept the belief that engineers of our day, in spite of their advances in scientific knowledge, are incapable of building a good pumping engine, and it is far more probable that these high duties are the results of very short, and imperfectly constructed, experiments. It must be remembered that there is a limit to the ability of steam to do work, even allowing it all that is claimed by Mariotte.

THE CRASH OF THE GUNS.—An amusing incident occurred at Portland on the occasion of the reception of the Peabody funeral fleet. Snow and sleet had fallen the day before, followed by rain during the night. In the morning the double-turreted monitors, *Terror* and *Miantonomah*, presented a beautiful appearance under the rays of the sun. Ice had formed two inches thick upon the stays, guards, flagstaffs, hurricane decks, turrets, and chains; icicles were pendent from the 8,000 square feet of gratings which form the hurricane deck. At the first fire of the heavily-charged 15-inch guns, the whole mass of ice came down with a crash upon the heads of the officers and men. The windows in the pilot-houses breaking at the same time, frightened the Portland pilots so badly that they sprang from the pilot-houses to the guys, slid down some 40 ft. to the decks, and took to their boats, under the impression that the monitors were sinking.

LEAD MINES OF MISSOURI.

From "The Iron Age."

The St. Louis "Journal of Commerce" recently published an article upon the lead mines of Missouri, to which we are indebted for the facts and figures here given. It says: Unfortunately no provision has been made to secure facts and statistics as to the present number of mines being worked, miners employed, nor the yield of different mines. Hence, we can only refer to statistics collected some years ago, as to the annual product of some of the largest and oldest mines."

There is probably no country in the world so rich in lead as Missouri. In the report of the State Geologist, made some 15 years ago, it was stated that there were "more than 500 localities, old and new, that promise good returns to the miner." What the number is now can only be conjectured, but it is safe to presume the number has more than doubled, as new discoveries are being constantly made. At different times, since the close of the war, lead has been discovered (partly by miners and prospectors, and in part by new-comers, while improving their newly-settled lands), which discoveries extend from the southwestern lead field eastward, through the counties of Lawrence, Barry, Christian, Stone, Taney, Webster, and into the edges of Wright, Douglas, Ozark, and Texas counties, thus greatly enlarging the area of country known to be underlaid by lead-bearing rocks. The State Geologist reported: "We have not examined a single county south of the Osage and the Missouri without finding in it more or less of this valuable mineral." It may be safely concluded that nearly all the counties in Southern Missouri are underlaid by the lead-bearing rocks of our State. The Commissioner of Agriculture, in his report for 1868, says: "Lead is found in greater or less quantity throughout the metalliferous regions of Missouri; and it is asserted that in no part of the world is there so large an area of lead-bearing rocks, so uniformly disposed, so regular, so readily identified, or on so grand a scale."

Most of the mines which are being worked are shallow. At Granby the lead comes to the surface of the ground. At the mine of Price, Bray & Co., 2,000 lbs. of galena have been taken from a shaft which is only 10 ft. deep. The ore at Mineral Point is in some places 18 in. thick.

	Pounds of Lead.
Total yield of Perry's mine to 1854....	12,000,000
" " Valle's " "	13,000,000
" " Franklin's mine from 1824 to 1854....................	20,000,000
Yield of Shibboleth mine in 1841......	3, 00,000
Yield of Washington and St. Francois counties from 1841 to 1854.....	50.000,000
Annual yield of Washington county...	3,000,000
Total " Virginia mine........	10,000,000
Yield of Williams' mine in nine months of 1854......................	145,000
Yield of Frazer's mine in one month..	100,000
" " in one week...	50,000
Shipped from Selma alone, from 1834 to 1854......................	70,000,000
Annual average of all mines from 1840 to 1854......................	4,000,000

Receipts of lead into St. Louis for the past 9 years have been as follows:

Year.	No. Pigs.	Year.	No Pigs.
1861............	115,259	1866............	146,584
1862............	95,800	1867............	144,555
1863............	79,823	1868............	186,823
1864............	93,035	1869............	172,583
1864............	64,500		

The stock of lead in that city at the close of the year 1869 was about 15,000 pigs. The product of Missouri lead mines for 1869 was about 172,638 pigs.

The lead is mostly a sulphuret. Out of 120 specimens of ore, 113 were sulphuret, 6 sulphuret and carbonate, and 1 sulphate. From 60 to 80 per cent. of the ore is pure lead. The gangue is generally sulphate of baryta. The ore is often found in magnesian limestone, or red clay, interspersed with brown hematite, pyrites, and ochre.

The contract for the construction of the bridge over the Schuylkill River at South street, Philadelphia, has been awarded to John W. Murphy for $770,000. The bridge is required to be constructed of wrought-iron, to have cast-iron piers in the river with stone abutments, arches of brick and girders of iron. Its entire length is to be 2,419 ft., the truss spans to be each 185 ft., with pivot draw giving an opening of 77 ft. on each side.

IRON BRIDGES.

From "Engineering."

From the introduction of iron bridges down to the present time, there has been a growing tendency on the part of engineers to increase the strength of the superstructure, not only with the view of providing for the passage of heavier rolling loads, but also of reducing the intensity of the normal strain upon the metal. In this respect the development of iron structures has pursued a diametrically opposite path to that of works constructed in timber or masonry. Should we wish to cite examples of heavy scantlings in roofs, we must go back to the middle ages, and those roofs would then be found associated with walls of very different proportions to those provided by the Metropolitan Building Act.

There must be some reason for this difference in the treatment of iron structures, and we think it will be found in the exaggerated estimate originally formed of the strength of iron. Early experimentalists derived their information concerning the strength of wrought and cast iron from the fracture of pieces of iron wire, and of castings, some ¼ in. thick, and in both instances we now know well the results so arrived at would be nearly double those attained in full sized structures. Again, iron was considered to be so trustworthy and uniform in quality, that it might safely be loaded with one-third of the breaking weight, although the timber used in connection with it would ordinarily be loaded with little more than one-twentieth of the same.

Whatever the reasons may be, the fact, at least, is indisputable, that for the last quarter of a century engineers have very generally adopted the system of making each succeeding iron bridge a trifle stronger than its immediate predecessor; and the result of these accumulated increments is that modern bridges are very weighty and expensive affairs. It is especially incumbent upon engineers, therefore, to bear in mind constantly the axiom that the true science of bridge building consists in making a sufficiently strong structure with the minimum expenditure of material, and that there is nothing necessarily clever in making a very strong bridge.

There is no good reason to suppose that the majority of existing iron bridges are not sufficiently strong for the requirements of future traffic. Some three years ago a slur was attempted to be thrown upon the new Westminster Bridge by the promulgation of a statement that passage was refused for the crank shaft of the Hercules, weighing, with the lorry, some forty-five tons. The origin of this false report was exposed in our columns at the time by a letter from the engineer, but it was again reiterated in the columns of a contemporary last week. As Mr. Page's explanation was perfectly satisfactory, the public will be quite content to leave the determination of the exact position of this renewed statement in the scale of *mistakes* to "Touchstone" himself. Mr. Page's summing up will probably be simply—*mentitur impudentissime.*

A load of forty-five tons upon four wheels only is considerably in excess of any weight yet imposed upon steel rails, and it is, we think, hardly a fair load for an ordinary macadamized road. The load to be provided for in French bridges, according to the recent memorandum of the Minister of Public Works, is sixteen tons upon four wheels; our own Government inspectors usually assume a weight of thirty tons in their calculations, but the unit strain is taken at a higher amount on this side of the Channel. Some of the bridges on the Liverpool Central Railway have to be constructed to carry a load of sixty tons upon four wheels—a distinction they enjoy from their proximity to the Mersey Steel and Iron Works.

We hope that the Board of Trade will not be incited by recent proceedings in France to swaddle English engineers with any additional restrictions as to the strength of iron bridges. Attempted generalizations invariably entail extravagance in some instances, and there is no necessity for the interference of the Legislature, as few will deny that our engineers enjoy the confidence of the public to at least as great an extent as ordinary Government officials.

There are now 12,000 windmills in constant use in Holland, for drainage.

THE WHITWORTH GUN.

From "The Engineer."

On the night of Thursday the 4th inst., Sir John Hay called the attention of the House of Commons to the proposed expenditure on the further competitive trial of the Woolwich and Whitworth gun. We gather from Mr. Childers' reply that, notwithstanding all that has been said on the subject, and the total failure of the Whitworth gun at Shoeburyness on Wednesday, March 3d, a competitive trial is actually to take place ; and the utmost that the public can now expect is that the experiment will be reduced to the narrowest possible limits. Even under these circumstances we have reason to believe that about £30,000 will be wasted. So long a time has elapsed since Sir Joseph Whitworth's original appearance in public in the character of an artillerist, that it is, we think, worth while to recall to the minds of our readers a few facts in connection with his theories and practice. The subject possesses so much importance just now, that we feel little or no apology for reverting to it is necessary.

No one who cannot establish a good title has a right to claim assistance from the State in carrying out an invention. If the invention be intended to supply in one way a want already satisfied in another way, it becomes very difficult indeed to establish this title. Thus, before Sir Joseph Whitworth can legitimately claim aid from the Government in introducing his proposed gun, he is bound to show first, that his system of artillery is likely to prove very much better than that at present recognized by military and naval authorities as the best; or else, that being no better, or but little better, it is very much cheaper. The last claim may be dismissed at once without further consideration, for it is admitted on all sides that the proposed Whitworth gun and its projectiles must be much more expensive than the Woolwich gun and chilled shot and shell. Sir Joseph Whitworth, therefore, comes before the public weighted with the difficulty of showing that his system of artillery is so much better than the existing system that it is worth adopting notwithstanding its increased cost. Considering the bearing of such a proposition, we have first to ask ourselves, is the proposer trustworthy in the sense that he thoroughly understands what he is talking about? Secondly, has he tried the system at all, and if so, with what results? And, lastly, how far are the principles on which the system is based likely to conduce to the result which it is stated can be obtained from its adoption? Even Sir Joseph Whitworth himself will admit that the nation called on to spend large sums in testing his theories for truth or falsehood, is entitled to weigh these present theories by the theorist's past practice, especially so because the Whitworth system of rifling, etc., is not new.

In dealing with the first of these problems, we must bear in mind that Sir Joseph Whitworth knows nothing practically of actual warfare. This is, perhaps, but a small matter, but it is worth noticing. In the second place, he is, of all men living, the least likely to lend himself to the production of instruments of warfare of the rough-and-ready class. Such things are, to him, utter abominations. He has achieved, and deservedly, a world-wide reputation as the most accurate mechanician in existence. His machine tools are absolute marvels of perfection ; and this reputation and perfection result from the peculiar constitution of the man's mind. He is fastidious to the last degree in mechanical matters, and this fastidiousness, in its proper place, has produced the happiest results. But in actual warfare exquisite refinements of mechanism are absolutely out of place, and we maintain as a consequence, that Sir Joseph Whitworth is not—judging of him by his mental calibre—a man likely to supply our fleets and our armies with ordnance fitted to withstand the exigencies of modern warfare. In other words, he is about the last man to whom we should think of applying for a gun which would stand, as a good gun must, all sorts of service. So much for the first point. Let us now see how far his past practice supplies us with reason for hoping that Sir Joseph Whitworth is able to give the nation a better gun than it now possesses. Strange as it may sound to those who, like ourselves, are admirers of Sir Joseph Whitworth's genius, it is nevertheless true that his entire career as an inventor of small-arms and ordnance

has been marked by a succession of failures. That his successes have been numerous is also true; but every one of his successes depended on the presence of conditions many of which would be secured in the practice ground, few or none on the battle-field. He first came before the world at large with the Whitworth rifle. Government made him a grant of £15,885 to work out this invention.* The new weapon shot as rifle never shot before. It enjoyed an ephemeral reputation, which lasted just until the rifle was put to something like service. The use of the Whitworth small-bore rifle is now confined to the Rifle Brigade and the 60th Rifles, as far as the British army is concerned. All the Whitworth rifles in the Tower—in other words, our entire reserved stock of these weapons—have been advertised for sale. No foreign Government, to our knowledge, has adopted the weapon at all, the use of which is now practically confined to match shooting. Next came the Whitworth big gun. This, too, enjoyed a reputation of a sort. Mr. Whitworth was, we believe, the first to drive a shell through an armor-plate. His gun was thought to be very accurate, and he got no small number of orders; yet we are justified in stating that the Whitworth gun never yet gave satisfaction in actual warfare. About the first really severe test which it underwent was at the siege of Charleston, during the last American contest, seven years ago. The Federals possessed two 80 lb. Whitworth rifles, from which they expected great things. They became useless after firing less than 120 rounds each. From the report of General Turner, Chief of Artillery during the siege operations, we learn that the Whitworth guns first opened fire on Fort Sumter with shells at 4,000 yards' range. The use of shells had almost immediately to be abandoned, owing to their premature explosion, which seriously endangered the Federal troops in the advanced trenches. Only solid shot were then used. We quote General Turner's report as to the performance of the guns with these projectiles, as given in General Gilmore's "Engineer and Artillery Operations against the Defences of Charleston Harbor in 1863." General Turner writes: "There appeared to be much difficulty experienced at times in loading these guns by the projectile wedging when part way down. It could then be rammed home only by heavy blows by a handspike, or by attaching a powerful purchase. They were very unsatisfactory in point of accuracy, shooting very wildly, seldom hitting Sumter at 3,980 yards. In comparison with the 8-in. Parrot guns in the same battery, they fell short in accuracy, and subsequently one of them became disabled by the gun apparently sliding through the reinforce. The other being considered unsafe after this, its further use was discontinued." We have here a record of not one, but four failures. In the first place, the gun could not be used for shell firing; in the second place, it could not be depended upon to hit what it was fired at; thirdly, it was loaded with the utmost difficulty; and, lastly, it could not be fired at all. On every conceivable point the Whitworth system failed before Charleston in 1863. It may be urged that many improvements have been effected since then. To find out whether this is really the case or not, we must turn to later tests; of these we have two—one in the performance of the gun in the Brazilian war, the other in its performance at Shoeburyness. The Brazilian officers report dead against the Whitworth gun. It was impossible to load it after a few rounds, although the most extraordinary devices were used to keep the bore clear, even to bringing a hose from the boilers of the steam ships engaged, through which hot water was forcibly blown into the gun after each discharge. Even with this, many times over the gun had to be fired with the shot not home. It is said that the powder was bad and fouled the gun, but this is no excuse. If the weapon is not able to get on for a couple of days, burning bad powder with no worse result than reduced range, it is not fit for actual warfare. But tested in the practice ground, Sir Joseph Whitworth's system did not do better than it did in Brazil. The Ordnance Select Committee reported against it in 1861, after experiments which cost the nation £10,278; and the last and best gun that Mr. Whitworth has made failed lamentably at Shoeburyness on Wednesday the 3d instant. It shot so wildly that at 200 yards range the projectile never went near the point aimed at. The projectiles, made of the new and professedly

* The hexagonal rifle was invented by Mr. Brunel, not by Mr. Whitworth.

tough metal, went to pieces when in the form of shells—one breaking up on striking the target, to which it did little harm; while the other went to bits in the gun. The second shot of the three fired was, indeed, tolerably successful, but only because Sir Joseph Whitworth had borrowed the ogival head from Major Palliser. Indeed, he had not on the ground one of those flat-headed punching bolts which were intended to do such wonders against oblique or any other targets. His so-called "flat-fronted" shot is simply Palliser-shaped shot with the ogival head truncated. Finally, we cannot find that a single nation of any importance has adopted the Whitworth gun, or having tried it speaks favorably of it. And yet this system, whose history is a record of failures, is to be put into competition, at a great expense, with guns which are admitted, by the very gentlemen who propose the test, to be "perfectly satisfactory."

We shall now consider, as briefly as possible, how far the Whitworth system appears to possess the qualifications necessary in a good gun. The Whitworth gun about to be put before the world is peculiar—first in respect to its rifling, secondly in respect to its material. The rifling will be of the well-known hexagonal type, the projectiles of great length, and machined to fit the bore. We really believe it to be impossible to devise a form of gun more likely to foul than this; or, in other words, a gun the minimum quantity of fouling in which can do more mischief. As to easy loading when in service, that is not for a moment to be expected, unless some device is introduced which has been hitherto wanting in all Whitworth guns. Then, be it observed, it is part of the system that the gun should be of small bore, though the projectile is very heavy. In order to acquire sufficient initial velocity, therefore, Sir Joseph Whitworth uses the strongest rifle-powder he can get; and not only this, but a tubular cartridge specially designed to secure the burning of the powder with the utmost speed; and this, be it observed, just at the time when we are beginning to use pellet powder to spare our guns some strain. But even with this the initial velocity is less than that of the service guns firing an equally heavy projectile. Is there in all this any reason to conclude that the system is likely, on theoretical grounds, to prove satisfactory? If there be, we confess it has escaped us. Lastly, we have the new metal to deal with. If it can be shown that this metal is really better than any we have got now, then by all means let us have it; far be it from us to say that because the Whitworth system of rifling fails, Whitworth metal must be bad too. But what is Whitworth metal? All that is generally known is that it is steel cast under compression (we shall have something more to say on this point at another time), and that the projectiles made of it and fired the other day at Shoeburyness behaved much as the worst cast-iron that could be found would have done. We are told, by way of excuse, that it is very difficult to temper Whitworth metal, and that the shot and shell which failed, did so because they were imperfectly tempered. If such difficulties are encountered in the process, that one projectile out of three must be deemed a failure, we presume that, as the guns must be tempered too—and they are much more difficult to deal with than shot or shell, because they are bigger—not more than one gun out of three will be a success.

Even the "Times" begins to show signs of deserting Sir Joseph Whitworth. Will some of his friends come forward and vindicate his system of rifling and his new metal from the charges brought against both, or are we to assume that the case is so bad that nothing can be urged in favor of one or the other?

Bessemer Steel Making in France.—The total production of Bessemer steel rails in France in the first six months of 1869, amounted to 19,755 tons, against 10,562 tons in the corresponding period of 1868; it is probable that the French production of this description of rails will show a still further advance in the second half of 1869, as large orders have been given out during the last two or three months by the great French railway companies. Among the more recent orders of steel rails, we may mention one for 2,000 tons, given by the Orleans Railway Company to the Creusot Works, at £11 7s. 2d. per ton, and another for 3,000 tons, given by the Western of France Railway Company to the Terre-noire Works, at £11 10s. 3d. per ton.

ELASTICITY IN THE TRACK AND ROLLING-STOCK.

From "The American Railway Times."

No matter how perfect the track and superstructure may be, the more perfect the elastic system of the rolling stock, the better it is for both. The true secret of the success of many of the ill-built American railways is in the elastic character of the rolling-stock; by this we mean the arrangement of springs for taking up the shocks at the many uneven points at the track, and the flexible character of the rolling-stock, enabling it to pass curves easily. The general character of the road-beds in this county is far below that of the prominent roads in Great Britain and on the Continent. The larger and better roads there approach perfection; that is, they are smooth and straight in comparison with American roads, so that engines and cars with little elasticity and long wheel-base are run with very good results. The same rolling-stock put upon American roads would pound itself to pieces very shortly. While foreign engineers have made the character of the road-beds a matter of the first importance, the Americans, by the bad character of theirs, have been compelled to pay more attention to the elastic principle in the rolling-stock. The Americans can well imitate their foreign brethren in the excellence of their road-beds, and they, in return, pay as much attention to the elastic principle in rolling-stock. The nearer they both approach perfection in both respects, the longer "life" is insured to both the track and rolling-stock. A gentleman informs us that he has often ridden over a Prussian railway, in a car 30 or 40 ft. in length, with hardly any springs, and though the movement was hard and rigid, yet it was very smooth, while the expenses of road-bed repairs were very small compared to those of this country. Such a road-bed as that, with the better class of American rolling-stock, would seem to approach perfection in railway travel, giving the maximum of comfort to the traveller, and the minimum of expense in operation.

Starting with a well-drained and well-ballasted road-bed, laid with a rail stiff enough to allow no deflection between the sleepers, or at the joints, and add to this rolling-stock, arranged to take up the concussion from all vertical or horizontal blows resulting either from slight obstructions on the rail or a possible defect at the joint, or from sharp curves, and it would seem that the combination is as near perfection as is possible with our present ideas of the allowable cost of railway construction. The devices for securing the requisite elasticity in the track are many. In the first place we rely upon the ballast and the wooden cross-tie; then again chairs are packed with wood or rubber, or some other material more or less elastic. All these are very important, slight as they may seem to the uninformed. Then, in the rolling-stock, there are many devices for taking up the sidewise or lateral motion at high speed; then in passing curves we have Fairlie's device, enabling engines of long wheel-base to pass curves of very sharp radii, and Bissell's and Hudson's arrangements for the same object, both of great value; then for Tenders, we have Bissell's device, allowing entire flexibility between the back and forward trucks so that all abrasion or crowding of the wheels against the rails is prevented even in the sharpest curves, giving longer "life" to wheels and axles, and much greater ease in carrying the load. Grigg's Elastic Wheel, for both locomotives and cars, is another very important improvement, saving the wear of wheels, tyres, and every other part of the rolling-stock. The well-known swing-beam device in long passenger cars is another standard improvement of great practical value, so far as comfort or economy is concerned. So far as we can apply elasticity and flexibility without destroying the requisite steadiness of movement, we are proceeding in the right direction, saving at the same time the road-bed, superstructure, and rolling-stock, and are in fact obeying the true mechanical and natural law.

A BRASS door, weighing 1,456 lbs., and costing $850, has recently been manufactured in England for the Wolf Rock Light House. It is intended to replace a solid oak door, four inches thick, which had been shattered into fragments by the force of the waves.

MASONRY: DESIGN AND CONSTRUCTION—THICKNESS OF MORTAR-JOINTS IN MASONRY AND BRICK-WORK.

From "The Builder."

The following remarks were commenced in reply to a question in the "Builder" as to the advantages, or otherwise, of thick or of thin beds of mortar. They have been extended.

The quantity of mortar which may safely and with advantage be used with bricks, must in a great degree depend upon the quality of the mortar, and the purpose to be served by the brick-work. Some mortars swell (expand) in use; others shrink. The best samples of mortar in setting become hard and tough; poor samples remain soft, and crumble on exposure. A thin bed of the best mortar for such a work as a tall chimney would not be so strong as a thick bed, because in a thin bed there will be parts where the best bricks will be in contact, even where $\frac{1}{8}$ in. thickness of bed may have been specified for, and this thickness of bed and joint may show on the face of the work. With common bricks, a bed of $\frac{1}{4}$ in. of mortar will leave rough projecting portions of the bricks in contact. Good mortar, when set, is, as we have just said, hard and tough; and to secure the whole strength it is capable of giving, the entire bed and joint must be full, so that the whole area of beds and joints of bricks shall be cemented by intervening mortar. Bricks and tiles of the best kinds, and mortar as composed and used by ancient Roman builders, appear to be indestructible under any ordinary action of the elements. Samples of Roman masonry—rubble and brick-work—occasionally dug up in London, and at other Roman sites in England, do not show any signs of decay, and in Italy entire structures remain sound and firm, with the exception of mutilations purposely made, wantonly or during war, in attempts to utterly destroy them. In these old works and ruins the proportions of mortar are usually about one-third, and sometimes one-half. The best rubble-work now consists of one of mortar and grout to three of stone, and the soundest rough brick-work, as in bridge abutments and retaining walls, one of mortar and grout to four of bricks. There are arches of Roman work constructed of flat tiles set in beds of mortar almost, if not quite, as thick as the tiles, and those structures which have been destroyed by man (probably in war) show sound fractures and materials undecayed.

The strongest work at the Liverpool docks is the granite rubble, consisting of one of mortar and grout to three of stone. The late Jesse Hartley, during the last twenty years of his life and practice, constructed dock and river walls of granite rubble masonry. The first twenty years he used ashlar masonry, hewn to an exactness and truth such as no other engineer ever obtained; the blocks of stone varying from 20 cubic ft. up to 200 and even 300 cubic ft. These blocks were set, stone and stone, over the entire areas of beds and joints, the backing being rubble. It is, however, the rubble backing which gives strength and endurance; and this will be sound when the ashlar has been crushed, or has decayed.

If these remarks are read by any young architect who wishes to construct cheap, sound, and enduring works, we recommend rubble to his notice for heavy masonry works, and brick-work thin, hard, and well-burned bricks, set in thick beds of good mortar. Even for public buildings the rule holds good, as at Windsor Castle, where the rough-faced wall stones are set with thick beds and joints of good mortar, stuck with spalls of flint. Compare the resistance of this work to atmospheric influences with the masonry at Westminster in the Houses of Parliament. The walls of Windsor Castle will be sound, in their rough strength and beauty, long after the elaborately-carved stone-work of the Westminster Palace has mouldered away. The cost of the two sorts of masonry is very different, probably as one to five, and in some cases one to ten—the rough work being, of course, the cheapest.

With regard to masonry and brick work construction generally, very much more more may be said, and especially about design. The "five orders" continue to be the alphabet for one set of architects: Gothic is the style chosen by another set, the Rennaissance and the Elizabethan style of architecture influencing others. Our

modern club-houses, public offices, and private residences give us rusticated basements, windows with pediments beneath string-courses, and heavy cornices which bolts and cramps can only keep in place. Columns should have something to support which could not otherwise be supported. Pilasters should give strength where it is required; pediments, string-courses, and cornices should act as protections from the weather, and ought not to be present where it is impossible for this purpose to be served. Rusticated ashlar masonry is not necessarily stronger, by reason of the amount of projection given to the face, as the true strength is in the breadth of bed, truth of workmanship, and in the care and mode of setting. If the breadth of bed to ashlar masonry is cut away to form a deep rustic joint, then is the work so much weakened by the process. With respect to design and construction in masonry, will one architect consent to design a public building in an original manner, regardless of all example and precedent, and not use one moulding or ornament which does not grace construction and is useful? Let him think over the purpose or purposes to be served by plinth, rustic, column, pilaster, architrave, pediment, impost, arch, key-stone, balustrade, string-course, cornice, and every other detail, and discard one or all if plain work will be sufficient. Ample scope for ornament may be found in the useful, and it will then be discovered that economy and power of endurance are on the side of that which is useful, and also that consistent decoration is most beautiful. Masonry will then be in keeping, as there will be harmony and breadth. Old Lambeth Palace, consisting of rubble, shames florid structures in endurance; and the noble massing and fine outlines of Windsor Castle would not be improved converting the walls into finely-tooled or polished ashlar masonry. London smoke, dust, and dirt soon disfigure hewn ashlar, which is deeply rusticated, and elaborately moulded; and carved masonry, such as that executed at the new Houses of Parliament, must inevitably and rapidly decay. The Windsor Castle coursed wall-stone is dirtied, but is not decayed as hewn moulded and carved masonry is. Thin courses of hard wall-stone and thick beds of good mortar last longest, even in palaces and in churches.

WASTE OF LABOR IN BUILDING.

From "The Scientific American."

Of all the painful sights we are called upon to witness in this day of steam engines and labor-saving appliances, none strikes us as being so absurd and unnecessary as the waste of human toil in building as it is generally conducted. Hod men crawling up long ladders with small burdens of bricks and mortar, carrying at each trip some sixty or seventy pounds of building material, with thirty or forty pounds of hod, and one hundred and sixty or more of flesh and blood—not to mention beer—seems something so foreign to this age of machinery that we should scarcely feel it more incongruous to see the stocks and pillories restored to our market places.

If a huge beam or girder is to be raised, we see the crane, tackle, and steam-engine employed, but the ordinary carrying is done by human legs. These legs, although they can do climbing passably, are certainly inferior in this respect to other legs designed by nature to make climbing a specialty.

A ladder is a very serviceable appliance in its way; we, however, believe it to be as hard a road to travel as ever the genius of man devised. The hod belongs to an ancient and honorable family of implements, but it does not seem the most agreeable companion in the world to clasp in affectionate embrace or place one's cheek fondly against.

Therefore we say, down with the hod; let it take its place with the host of implements, on the tomb of which modern progress has written the epitaph—"PLAYED OUT."

Let us suppose the two side pieces of a ladder to be replaced by iron rails and the rounds by ties, and let us suppose some genius to conceive the happy idea of causing a locomotive to crawl tediously up this heavy grade, drawing after it a load of one third its own weight. What gibings,

what laughter, what derision would such a scheme excite among mechanics! Yet we are importing annually large numbers of locomotives to do the same thing; only these locomotives run on the ties instead of the rails.

They do these things better in France. Either derricks are employed, or the brick and mortar carriers are used as stationary engines, rather than as locomotives. In passing a building in process of erection in Paris, one may often see a number of men stationed one above the other along a ladder, each of whom passes his load to the next above him, until the load reaches its destination. In this way a continuous procession of materials is kept up, and a large quantity may be elevated in a short time.

This is an improvement on the climbing process, but there must even in this way be an enormous waste of power. And this waste is not only useless, but so easily avoided that the continuance of the employment of human power to perform such rude work is a disgrace to modern civilization. It can be demonstrated that a small one-horse power engine, with suitable tackle, and the employment of a single man to attend it, will do the work of six men at elevating bricks and mortar, at a cost of less than the wages of two men.

No mechanic who reads this will fail to see many ways in which this application of steam power could be advantageously made. The ladder might be replaced by a railway up and along which a car-load of bricks or mortar might be made to roll, which track might be joined to and made continuous with a horizontal track, by means of an easy curve at the summit, the whole being adjustable to suit the progressive heights of the wall as they advance towards completion. It would require little genius to adjust the detail, and the cost of building would be greatly lessened by dispensing with the hod-carriers.

THE HARVEY TORPEDO.

From "Engineering."

The development of the torpedo as a weapon of naval warfare received an impetus from the practical results of its use in the American war. Since that time many improvements have been introduced in its construction, and all the refinements of modern science have been called into requisition to render it as sensitive and as deadly as possible in its operation. The question is one in which all maritime nations have taken a greater or less interest, and we have from time to time recorded the results arrived at now by this foreign power, and now by that. America has been busy perfecting a system of torpedo boats and gear, which is reported to be very complete and efficient. In Austria the authorities have been carrying out a series of experiments in the same direction with a self-propelling, self-guiding submarine torpedo, worked by compressed air, the performances of which are stated to have been as satisfactory as they were extraordinary. Russia has taken up the question in a practical manner, by sending a commission to England to investigate the merits of the Harvey torpedo, which proved so satisfactory that that weapon has been adopted into the Russian service. These unmistakable signs of activity in providing for this kind of warfare have at length roused our authorities at home to a sense of the necessity of at least no longer remaining behind other nations in this respect. So it comes that they have recently instituted a series of searching experiments with the Harvey torpedo, which forms the subject of the present notice. The inventor of this weapon is Captain John Harvey, R. N., who has for years past endeavored to convince the Government of the absolute necessity of having an arm of this description, which should be at once effective and reliable in working, and handy in use. The authorities, however, remained perfectly indifferent in the matter until they found a foreign power preparing to arm itself with Captain Harvey's invention. The necessity then became obvious, and they forthwith instituted inquiries, and directed experiments, which have proved satisfactory, and which we believe will lead to its adoption in the British service.

Captain Harvey's torpedo consists of a stout wooden casing, strengthened on the

outside with iron plating, and containing a metal shell which holds the powder charge. A central transverse section of this case shows a rectangle; in plan it is a rhomboid, the ends being angled to give the torpedo, when towed, a divergence of about 45 deg. from the vessel towing it. The movements of the torpedo are controlled from a vessel specially constructed with a view to great speed, and so arranged as to render the action of the enemy's shot, when bow on, of but little consequence to her. The form of the torpedo, and an arrangement of slings in connection with it, enable the operator to diverge the shell alongside the enemy's ship in meeting, passing, or crossing, whichever method of attack is adopted. The torpedo is fitted with a very simple arrangement of outside lever, acting upon an inside discharging apparatus; the explosion being effected when the weapon is in hugging contact with the enemy's vessel. The shape of the shell insures a large amount of surface in contact with the ship's side when exploded, whilst at the same time it offers very little resistance in towing. The depths of immersion of the torpedo below the surface of the water can be regulated by the speed of the vessel towing it. A buoy is attached to the apparatus, which is of sufficient displacement to support the shell at the extreme depth required, and also to recover the shell if necessary. A safety key is fitted which relieves the operators from all fear of accidental explosions, as until this key is withdrawn the exploding apparatus will not act, and the key is never withdrawn until the shell is some yards astern of the torpedo vessel. The size of the shell varies with the amount of the explosive compound it is intended to carry, the ordinary quantity being about 70 lbs. of powder. The explosive agent used is known as Horsley's powder, a most violent fulminate composed of chlorate of potassa and gall-nuts in proportion by weight of three to one. The ingredients are kept separate, and are mixed in sieves at the time of use; they form an admirable charge for the torpedo, the disruptive action of the powder in relation to the best gunpowder, volume for volume, being something like 15 to 1.

Such is the Harvey torpedo and its charge, and it was with several of these shells—uncharged, of course, but fitted with the exploding bolt—that a series of experiments were recently carried out at Portsmouth by direction of the Admiralty. The Camel steam tug was used as a torpedo craft, and was fitted with the necessary paying-out apparatus, which is provided with simple but powerful friction brakes. Captain Harvey conducted the operations from the Camel against the Royal Sovereign converted turret ship, which was in command of Captain Boys, R. N., of the Excellent, and who had charge of the official trials. The object of the Camel was, of course, to strike the Royal Sovereign with the torpedoes, the latter doing her best to avoid being struck. In the first part of the operations the Royal Sovereign remained at anchor, the Camel towing a 76-pounder torpedo with 50 fathoms of line at an angle of 45 deg. from her wake. The speed of the Camel was about 8 knots an hour, and under these conditions 10 attacks were made upon the assumed enemy. In every case the torpedo struck the Royal Sovereign at depths of from 1 to 16 ft. The position of the Camel was varied each time; sometimes she was right ahead, sometimes right astern, and at other times crossing. In order to estimate the chances of ridding herself of the Camel, the Royal Sovereign opened fire from her turrets. In two instances during the attack she fired 4 and 7 shots respectively, but in each of the rest she never got off more than 2 rounds. After each trial the working parts of the torpedo were examined, and it was found that in every instance the exploding bolt had acted. The safety key was withdrawn at distances ranging from 8 to 60 yds. from the Camel with ease and unvarying certainty.

The Royal Sovereign got under weigh for the second series of attacks, which were made with the Camel steaming at about 11 knots, the Royal Sovereign running at a speed of from 8 to 9 knots. A torpedo was carried from each quarter of the Camel, with 50 fathoms of tow line, and a divergence of 45 deg. in each case. A series of well-executed manœuvres were intended by Captain Boys to place the Royal Sovereign beyond the reach of the torpedoes. He could not, however, elude the Camel, and in the 6 trials made, every torpedo invariably struck the adversary. The points of contact varied, as before, from 1 to 16 ft.; 2 struck directly under

the ship's bottom. The method of attack observed by the Camel varied as in the previous experiment; sometimes she came up from the stern, sometimes down from ahead, whilst at others she crossed the bows of the Royal Sovereign. The latter ship again tried the number of rounds she could fire during each attack, and these varied from 2 to 12.

The results of these trials proved the torpedoes to be perfectly under command, and thoroughly effective in action. One great feature of the torpedo is that all its arrangements are simple and sailor-like, and it is exactly fitted for the class of men within whose province it will lie to use it. The paying out apparatus and its brake arrangement are also readily worked by an ordinary seaman; in fact, from first to last there is nothing that requires a specially experienced staff to work this torpedo. The manufacture of these weapons is carried out by Mr. Nunn, of St. George street, East, who has introduced several improvements into our marine signal lights, and who deserves credit for the substantial manner in which the torpedoes are constructed. We examined them after the trials and found several of them had been severely knocked about, showing the rough usage to which they had been subjected. They, however, still hung well together, although the iron plates were in some places ripped from the outer skin. One point demonstrated by the recent experiments ought not to be lost sight of, as it is of great importance, and that is, that if the torpedo is laid to a passing vessel, and she should prove to be friendly, her destruction can be arrested. This was effected by so managing the tow rope as that the torpedo cleared the approaching vessel. On all points, then, it seems clear that in the Harvey torpedo we have an efficient apparatus, well adapted to its special purpose, and possessing all the necessary requirements of such a weapon. The Government, having proved its merits, will, we presume, recognize them by adopting it into the service without further delay. It seems pretty clear that naval supremacy in the future will be with that maritime state which is the best practised in torpedo warfare, and which has a navy adapted to the service of the arm.

EQUILIBRIUM OF FLOATING BODIES.

Translated extract from "Exposé de la Situation de la Mécanique Appliquée."

The investigation of the action of a liquid or a gas on a solid body immersed in part or entirely, is one of the oldest problems of physics. Archimedes discovered its solution, and said: "Every body immersed in a liquid loses a part of its weight, equal to that of the fluid which it displaces." This statement is not rigorous, and every day gives rise to some misconception. It is one of the resources of those who attempt to invent perpetual motion. An inventor, for example, will refer to the principle of Archimedes in maintaining that a massive cylinder, movable about an axis supposed to be horizontal, and forming the lateral wall of a vessel entirely filled with water, tends to turn indefinitely upon itself without expense of liquid; because the part submerged in the water loses a part of its weight, while the other part maintains its total weight. If, instead of this misleading conception of a loss of weight, the inventor would think of the forces exerted by the water upon the cylinder, he would perceive that they are all directed towards the axis of rotation, and that they could have no tendency to set the cylinder in motion. The principle of Archimedes must then be suitably interpreted; and had it at first been announced with strict scientific rigor, it would not have so numerous a brood of illegitimate offsprings clinging about it. It can be asserted that out of ten projects of perpetual motion, there are seven or eight whose authors refer to Archimedes, thinking that they have found an incontestable support in his famous principle.

The problem of the stability of equilibrium of a body immersed in a liquid, presents two distinct cases—one very simple, in which the whole body is submerged; the other much more complex, that in which the body floats on the surface of the liquid. In the first case it is necessary to equilibrium that the weights of equal volumes of the body and of the liquid

should be equal, and that the centre of gravity of the body, and that of the displaced volume, should be in the same vertical; for stability, it is necessary and sufficient that the first of these two points should be below the second.

In this case the resultants of the action of gravity, and of the forces from the liquid, have definite points of application, which remain fixed in the body when its position is disturbed. A body entirely submerged is in a condition like that of a heavy body suspended by a thread. In considering the second case, that in which the body floats and is partially sunk in the fluid, we still perceive that the weight of the body is equal to that of the fluid displaced by the submerged part, and that the two centres of gravity—that of the body and that of the displaced fluid—are situated on the same vertical line. But the question of stability becomes more intricate. If a sufficiently small displacement is given to the floating body, this generally modifies the form and volume of the displaced liquid so that the point of intersection of the resultants of the forces, —the point which may be called the centre of careening—does not maintain a fixed position in the body. The body cannot therefore be considered as suspended by a thread attached to a definite point. To carry out the simile, it would be necessary to consider the point of attachment as movable in the body; which does not give a clear conception to the understanding.

In a practical point of view the problem of the stability of a body was solved long ago, for navigation supposes the solution known; and from ancient times vessels of sufficient stability have been constructed. But it was not till the 18th century that an attempt was made to establish a theory. The first, due to Bouguer, very ingenious but not sufficiently general, depends upon the consideration of the *metacentre.** The metacentre has an exact definition only in the case of a floating body which has a vertical plane of symmetry. If this plane of symmetry receives a slight displacement, under the condition that the immersed section remains constant, the centre of buoyancy will describe an element of a curve perfectly determined. The metacentre is the point in which, after displacement, the vertical drawn from the new centre of buoyancy cuts the position taken at the same instant by the straight line containing the only centre of buoyancy and the centre of the body. It is, in other words, the centre of curvature of the locus described by the centre of buoyancy in the very small displacements impressed upon the body under the specified conditions. That the equilibrium may be stable it is sufficient that the metacentre should be above the centre of gravity. If the body has two planes of symmetry, a particular metacentre corresponds to each; and it is necessary to stability that the lower of the two should be above the centre of gravity of the body.

This theory, it is obvious, is very incomplete. It supposes that the floating body has a plane of symmetry. Indeed, if we attempt to apply it to a body not having a plane of symmetry, or if, supposing the body symmetrical with reference to a plane, the position of the metacentre for a displacement not parallel to that plane is sought, it is defined by the directions of two lines which do not intersect. Even if the displacements are restricted to those which are parallel to the plane of symmetry, an infinite number can be imagined; yet the theory considers but one. It therefore reduces the generality of the problem, by an arbitrary choice of the only displacement in which the transverse area of the buoyant volume remains the same. Now, if it is wished to rid the investigation of this arbitrary limitation, an infinite number of possible positions for the metacentre are found, of which some may fall below the centre of gravity without causing the equilibrium to become unstable. The theory of the metacentre is, therefore, incomplete, and depends upon a course of reasoning which, if literally applied, may lead to error.

We now have a theory which seems preferable, because it has a much more extended generality. It is known that the discussion of the equation of living forces helps to determine the stability, instability, or conditional stability, of a system in equilibrium. It is, then, a return to general and rational methods to apply this equation to the investigation of the conditions of stability of a body floating on the surface of a liquid. M. Duhamel has developed this method. A floating

*Bouguer, "Construction des Navires," 1746.

body being in equilibrium, he supposes that infinitesimal velocities are impressed upon it; the body is consequently animated with a certain living force, upon which the work of external forces acts, either to increase or diminish it. The question reduces to the determination of the variation of the work of exterior forces as determined by the displacement of the body. In these forces M. Duhamel represents only the weight of the body, and the hydrostatic pressures of the liquid. The discussion of the signs of the terms of the equation of living forces serves to distinguish the cases in which the initial displacement can receive finite increments from the case in which the displacement of the body remains limited. The last case is that of stable equilibrium; the formula which gives this condition is, strange to say, the same which the theory of the metacentre would furnish in the restricted cases in which it is applicable. So the use of the equation of *vis viva* justifies, not the reasoning, but the results obtained by a coarser method. It is the rigorous demonstration of a rule discovered by a kind of divination, and afterwards verified by long experience.

Is the theory of M. Duhamel itself complete; and is the subject of the stability of floating bodies henceforth exhausted? Far from it. We have already mentioned that M. Duhamel, in this respect following the hypotheses of the theory of the metacentre, admitted into his equation only the static pressures of the liquid. This point of view is not sufficiently general; for it is a contradiction, to impress upon a floating body certain velocities, and to treat the mutual reactions of the body and the liquid as if the relative repose of the two systems had not been disturbed. The imperfection of the theory is perceived when we wish to determine the exact laws of the oscillation of floating bodies, but the investigation of the conditions of stability seems not to be seriously affected by this imperfection. It seems evident that the movement of a body in a fluid mass cannot but develop resistances of friction, whose work tends to reduce the living force of the moving body; if stability is assured without taking into account these various resistances, it is certainly so *a fortiori* when they are introduced into calculation. Experience confirms this estimate, for it shows that stability never has failed in vessels built according to the usual rule.

The question is, therefore, entirely solved in a practical way, without being so in a scientific point of view. Among the recent efforts to complete the theory, we cite the labors of M. Reech, which will give to the old theory of the metacentre a more rigorous character; those of M. Jordan and those of M. Clebsch, who has attempted to complete the theory of M. Duhamel by the introduction of the dynamic resistance of liquids. Viewed in this general manner the problem presents difficulties which have not yet been surmounted, and really belongs to the obscure domain of hydrodynamics.

THE MANUFACTURE OF COKE.

From "La Houille."

Coal is composed of carbon (the largest element) and condensed oxygen and hydrogen, mixed with a greater or less quantity of earthy matter. It also contains a very small proportion of azote, which, by distillation, produces ammonia water. Coal is not a compound of an invariable character, but a mere mixture of the above elements in very different proportions. It could not be otherwise, being, as we have said, only a mixture, and because in its geological formation it is like turf. We have tried more than two hundred samples of coal of all kinds, and we have never found two alike, unless they came from the same mine, and, in fact, from adjacent points in the same seam.

The proportions of earthy matter have an almost infinite variety; carbon, oxygen, and hydrogen vary only between certain limits. It is the relative proportions in which these elements are found which give to different coals their distinctive characters, and which determine the particular purpose for which they are employed in industry.

In different kinds of coal, oxygen forms a proportion of from $3\frac{1}{2}$ to $17\frac{1}{2}$ per cent.;

hydrogen from 2½ to 6 per cent.; and carbon from 77 to 94 per cent.

In rock of more recent formation than coal rock, mineral combustibles may contain these elements, and especially oxygen, in much larger proportions. Carbon may constitute a proportion of 96 per cent., hydrogen 9½ per cent., and oxygen 37½ per cent.

But neither by calcination nor by distillation can we obtain as a fixed product the whole of the carbon; there is always a certain part which escapes in the form of volatile matter combined with hydrogen. Calcination with different coals, the crucible being employed, gives from 55 to 93 per cent. of fixed coke, and from 7 to 45 per cent of volatile matter.

Coal may be *meagre* (that is, not forming one consistent mass or giving coke when heated in a crucible, an oven, or a retort) from three different causes: (1), by excess of carbon, as in the case of anthracite; (2), by excess of oxygen, as in the case of certain free-burning coal of the Saône-et-Loire and Sarrebruck coal-fields, which contain more than 17 per cent. of oxygen; (3), by excess of earthy matters.

The more the hydrogen element predominates the more bituminous the coal.

By slowly distilling the different kinds of coal (in a glass retort for example), we may obtain bitumen varying from the very smallest appreciable quantity to 16 per cent. of the whole substance (leaving out of the question a few rare and exceptional varieties which contain a still larger proportion). In regular coke ovens, then, the coal is distilled slowly, as in the glass retort, because it is operated on in large quantities, and the duration of the operation is thus not less that 24 hours.

It is bitumen which agglomerates the particles of coal during coking. Coal which gives no bitumen or scarcely any, as anthracite, cannot be converted into coke, even with the crucible, without the assistance of an admixture of more bituminous coal. That which gives a very small, or a small quantity of bitumen, is called *meagre* or *demi-meagre*. And, in this latter case, the small quantity which does exist is to be employed to the greatest possible advantage, in order to bring the particles of the coal together and make them adherent.

This object is only practically accomplished by submitting the coal to a very great and well-sustained heat, and by facilitating the union of the particles by the most suitable mechanical preparations.

By means of experiments with the crucible, we have observed the manner in which coal is converted into coke, and the necessity of very great heat in order to succeed in coking with *meagre* coal; and this observation of the process has aided us in our researches after proper means of facilitating this result.

When coal is submitted to a very great heat in a crucible, or compartment of an oven, the whole mass is not softened at the same time, nor is it at any given moment transformed into coke. On the contrary, the formation of coke takes place in a gradual and continuous manner, beginning from the sides of the oven and by degrees extending to the centre of the mass of coal. The heat of the fire passing through the sides of the oven enters a first portion of coal in contact with those sides, decomposing it, liberating the bitumen, softening it, and binding the particles together in the form of coke. A second heat again traversing this first portion now become coke, passes into the next portion, forming a second portion of coke. A third heat, passing through these two portions of coke, forms in like manner a third; and so on to the central portions of the mass. But the action of each heat thus exhausted in decomposing a single portion of coal, remains latent for the following portion, so that the coal always remains intact behind the portion in decomposition.

By experiments with our large oven, we have obtained the clearest confirmation of what we have just said. Four hours after a compartment had been heated, we opened the cast-iron door. The coal occupying the centre of the compartment assumed the same form as when it was inserted in the oven, and was even cold, The great heat which had passed through the sides of the compartment had exhausted its action in forming a cake of coke about 3.9 in. thick, which adhered to the sides and the interior surfaces of which were very smooth and glossy, and parallel to those of the compartment. At the inner surface of the coke the action of the heat was arrested, coal being a bad conductor. Some experiments two hours later, that is, six hours after the heating of the oven, gave similar results, with

greater or less thickneses of coke (according to the duration of the action of the heat), which adhered to the sides. It may be remarked that the thicknesses of the coke formed were not proportional to the duration of the heat applied; they were relatively less for a more prolonged heat. The reason of this is, that the portions of coke which have been formed, not being good conductors of heat, oppose more and more the rapid penetration of the heat. Thus the last portions of coke are longer in formation; and as each face of the compartment contributes its contingent of heat, a space is formed parallel to those faces and in the centre of the cake of coke formed. In this central space the particles of coal of which the new portion of coke is to be formed are conveyed to the last formed portion by the aid of the liquid bitumen, which acts as a vehicle. The space in which the bitumen is to circulate should, therefore, be restricted in the case of coal containing but little bitumen.

Having to deal with different kinds of coal—*meagre* and bituminous coal and coal slow to bake—it was important to be acquainted with these particulars, in order to determine the exact dimensions to give to the compartments to complete the process in a little less than 24 hours, and to ascertain with respect to each kind or mixture of coal the most suitable method of preparing it with a view to its more easy conversion into coke.

The appearance of coal forms but a very slight indication of its nature, or of the manner in which it should be treated in the oven. For this purpose, it is necessary to submit it to a preliminary trial in a crucible.

Incineration will show whether the coal is to be washed. If the coal is already more or less *meagre*, it would, under any circumstances, be advantageous to crush it (if it is not small), and wash it. We have observed, in fact, that coal may become *meagre*, that is, not forming a consistent mass in the coke oven, from excess of earthy matters. This earthy element is often almost completely distinct from the other elements in small coal, and in this case it may be removed by washing. But when the earthy element constitutes an essential part of the coal, it cannot be eliminated.

A trial with the crucible (conducted in a manner to approach as nearly as possible the usual process) shows whether the coal is rich in carbon, hydrogen, or oxygen, whether it will form a consistent mass easily or not, and whether it is bituminous or more or less *meagre* by reason of an excess of carbon or oxygen. The appearance of the coke produced will be a sufficient indication on these points, and will also serve as a guide to the method of treatment to be employed. By a measurement (before and after the operation) of the empty space remaining above the coal in the crucible, we discover whether the mass diminishes or increases in size by coking; and in this latter case, what mechanical preparation the coal should be submitted to.

Supposing that the coal is not too earthy (that is, that it does not contain more than about 2 to 8 per cent. of earthy matter), when the yield in coke with the crucible is between 78 and 83 per cent., it is *demi-meagre* by excess of carbon, and may generally be treated *alone* on a large scale.

If the yield is from 84 to 87 per cent., the coke is generally not very adherent, and coke-dust may be easily rubbed off with the finger. This is anthracite coal, which can only be treated on a large scale by the addition of a small quantity of more bituminous coal, and by properly pounding and mixing the two together.

If the yield of coke is from 88 to 93 per cent., then we have real anthracite, which will not agglomerate at all, and which remains in the crucible after being operated on in the same condition as when placed in it. To transform this coal, so rich in carbon, into coke, it is necessary to mix it with a stronger proportion of bituminous coal than in the preceding case. These two kinds of coal should be well prepared by crushing, and the bituminous coal should constitute at least one-fourth of the weight of the whole mixture, the exact quantity being determined by the exact character of the anthracite.

The smaller the bituminous coal is crushed, when it is to be employed with anthracite, the smaller will be the quantity required to bind the particles of anthracite together.

If, therefore, we wish to economize the bituminous coal, the two kinds should be crushed separately before being mixed together. To obtain a really useful coke, the bituminous element should constitute

one-third of the weight of the whole mixture. If the coal is *meagre* by reason of excess of oxygen, a very small yield of coke is obtained. A yield of 60 per cent. is almost the limit for this kind of coal, which will, however, agglomerate in coke-making on a large scale. But if the yield is less than 60 per cent., it does not agglomerate, or only in a slight degree, like anthracite coal and anthracite, which are too rich in carbon. This oxygenous coal resembles lignite, which also does not agglomerate, and which gives more than half its weight in volatile matter, oxygen forming the greater part.

The water which is introduced with the coal into the compartments of our oven does not generally injure its action nor the quality of the coke, unless an excessive quantity is used. A proportion of 4 to 5 per cent. of water produces, in fact, a more active combustion of the gases in the empty spaces of the oven. But certain kinds of coal, and especially *demi-meagre*, which is so from excess of oxygen, do not agglomerate so well if introduced very small and mixed with more than 5 per cent. of water. Coal which is rich in carbon does not generally present this inconvenience. But some kinds of this coal augment in quantity in coking, and with them a prudent preparation is necessary, in order to avoid difficulty in getting the coke out, and the derangement of the sides of the compartment. The following is the precaution we have taken:

Let us take a block of coal a cubic decimètre in dimensions (decimètre = 3.9 ins.) If we break it into little pieces it could no longer be place in a measure of the capacity of a cubic decimetre. It will be alike impossible if we reduce these pieces to small dust, by reason of the multitude of very small spaces between the particles. But if we add to this fine dust from 6 to 8 per cent. of water, by weight, it will occupy a considerably greater space. It may indeed (according to the fineness of the dust) occupy a space three times as great as the original block of coal.

It may be conceived, therefore, that coal thus increased in bulk previously, and introduced into the compartment, will contract rather than swell during its conversion into coke.

In an oven which would not be so high as ours, this fine coal-dust, swollen with the admixture of water, produces a porous and light coke. It is not so with our oven, because of its high temperature, and the great relative height of the mass upon which we operate, the principal causes of the density of coke. We have not found a great difference of density between coke taken from the base of the mass and that lying immediately next the extreme upper part. We have made numerous experiments on the density of coke produced from the same coal in ordinary low ovens and in our own oven, and we find that ours gives the densest coke.

We ascertain the density of coke (with respect to its apparent bulk) by means of the following formula:

$$d = \frac{p}{P - E},$$

which may serve for any kind of porous body not soluble in water. In this formula, d represents the density of the piece of coke, with respect to its apparent bulk; p is the weight of the coke weighed dry in the atmosphere; P indicates its weight after being made to boil for about ten minutes in water, and then cooled in cold water for twenty or thirty minutes, according to its size; E is its weight in water taken with the areometer, that is, the weight of the body less the weight of a volume of water equal to the bulk of its *real matter*. This formula remains true even when the boiling water might not penetrate into all the little pores of the coke. In this case the formula

$$D = \frac{p}{p - E}$$

would give the real density, D, of the matter of the coke, without regard to its exterior bulk.

A PROSPECTUS has been issued of the Franco-Egyptian Telegraph Company (Limited), with a capital of £410,000, in shares of £10, to eastablish "a direct line between England, France, Algeria, and Egypt, hereafter to be extended to India and China, as may be determined by the shareholders." It is to proceed through France to Marseilles, *via* the submarine line from Dover to Calais, and thence by cable to Algeria and Egypt, and is simply a competitive undertaking against the Falmouth, Gibraltar, and Malta, and the Anglo-Mediterranean companies.

HYDRAULIC RIVETING MACHINE.

Translated from "Annales du Génie Civil."

The important operation of riveting the plates of boilers has hitherto been done almost exclusively by hand. Machines have, indeed, been invented for that purpose, but are complicated and costly, and but imperfectly accomplish the end in view. All are constructed upon the same principle, and differ only in some specialty of motion, or in the means employed to move the riveting lever. A cast-iron anvil receives the point of the rivet, which is applied red-hot, and then pressed with great force. A second lever is sometimes used to force the plates together before the riveting lever is applied. Without this contrivance the plates are forced apart rather than together by the process of riveting.

When riveting is done in the ordinary way, not only is the part of the rivet projecting beyond the plate compressed, but that within the hole is also spread. This acts upon the plates, and tends to separate them, as illustrated in Fig. 1. If the second lever is used this difficulty is obviated, as the riveting becomes almost perfect in all respects, and much better than that done by hand. But, though the work of these machines is good, it is attended with many hindrances and inconveniences.

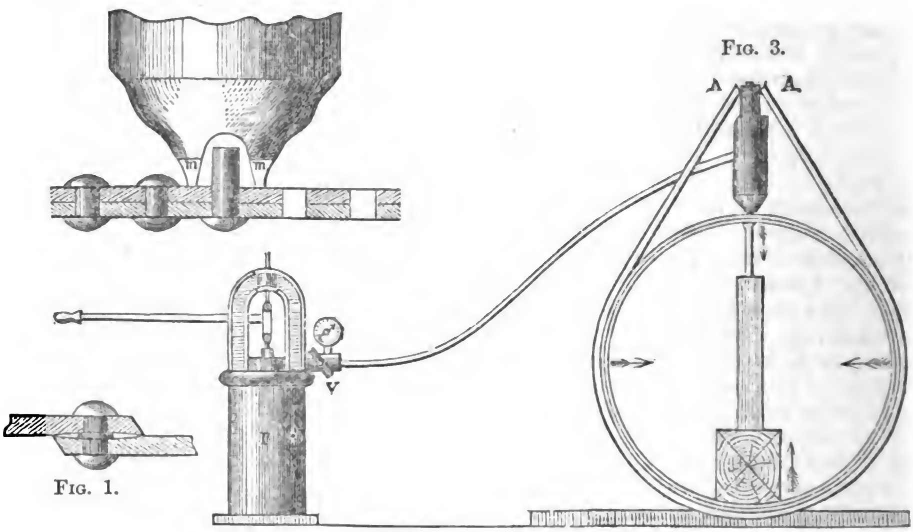


Fig. 3.

Fig. 1.

The height of the anvil ought not to be considerable, if sufficient resistance is to be opposed to the lever. The boiler must often be riveted in sections, ring by ring. It often happens that, in the manufacture of boilers 9 to 12 metres in length, of 7 to 10 rings, it is necessary to interrupt operations as many times, in order to push the boiler forward or back. Every one knows the disadvantages of such suspension of work.

Again, these machines can do riveting only upon cylindrical portions of the boiler; in other parts the work must be done by hand.

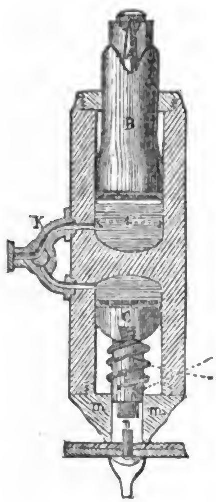
The conditions of a good riveting machine are the following: It should exercise a pressure as great as possible upon the plates without separating them, and while this pressure is acting, a stamp should be brought to bear upon the projecting bolt, so as to form the head of the rivet. Besides, the machine should be so light that two workmen can carry it and fit it to any part of the boiler where the equilibrium will not be disturbed by the additional weight.

It is evident that the machines heretofore employed do not satisfy these conditions. Fallenstein has solved this problem in a rivet machine which employs the hydraulic press.

The boiler is set as if the work were

to be done by hand. Fig. 2 represents a rivet machine (scale $\frac{1}{8}$) and Fig. 3

Fig. 2.



shows its application to the boiler. A fork A A serves to hold a strong chain which surrounds the boiler. This chain should be somewhat slack, so that the machine may be fitted to any part of the boiler, and it should move back 52 millim. after having finished each rivet.

The machine should be placed so that its axis coincides with that of the rivet hole. The bolt is put in red-hot; the small hydraulic pump P is then put in action. By the contrivance shown in Fig. 2 water is admitted by the valve K into the upper compartment, lifting the piston B. This tightens the chain, bringing *m m* against the plates, and forcing them together. The pressure must be determined by the thickness of the plates. Two strokes of the piston are sufficient. The stopcock K is now turned so as to keep the piston B under pressure, while the lower space is put into communication with the hydraulic press. The consequence is that the piston C is forced down, and the rivet is headed.

In order to vary the amount of pressure, the valve V is opened, so that the water can leave the pump; the pressure then ceases, and the piston C is raised by the recoil, thus gaining time, as otherwise a lever (indicated by the dotted line in Fig. 2) would be necessary.

The stopcock K is now set to its first position, the water which fills the upper space escapes, the piston descends of its own weight, and the chain slacks, so that the machine may be moved to the next hole.

HOW RAILS ARE MADE IN FRANCE.

From "The Iron Age."

PUDDLING PROCESS.

The hearth is cleaned out and made up once in every 24 hours; fragments of scrap-iron and ends of sheet-iron, bars, etc., are laid on the middle of the hearth and heated until the scrap and the silica left from the previous day are partly melted together. When there is one or two inches of molten matter, water is thrown over to solidify it, and a layer is formed which protects the iron-plate, and increases the yield.

440 lbs. of white pig iron, previously heated, is charged at a time; the grate is cleaned, and 8 inches of coal are charged; the slag of the preceding heat is drawn off; a very little cinder is added, and several handfuls of mill cinder. The door is accurately closed and full heat is given for 30 or 40 minutes. During this time the grate is charged five or six times. Hot pig is known by its fluidity, whilst cold or slightly carburetted pig is known by the specks and skins on its surface. The bath is then stirred; with good qualities of pig, 5 or 6 hooked bars can be used at the same time. With hard iron only 2 or 3 can be used at once, as the bath is very dry. During this operation the grate is charged rapidly twice, so as to admit no air. At the end of 10 or 15 minutes the hearth is covered with agglommerated and very dry lumps. The damper is then closed for 6 or 7 minutes, and without disturbing the fire, the balls are made so as to inclose the particles of iron immediately upon their coming to nature. Particular care is taken to leave no isolated fragments on the hearth, as they would be turned to completely fibrous iron; for the same reason the first balls taken out are more in grains, and the

last ones more fibrous. After 5 or 6 minutes of arduous labor the damper is opened and the furnace is fired up strongly for 1 or 2 minutes. The balls are then ready, and are taken at once to the hammer and the rolls.

20 charges are made in 24 hours. The waste is 12.5 per cent.; the consumption of coal is 10.5 hectolitres per ton of iron. 40 lbs. of scrap is added to increase the yield. Iron filings sometimes thrown in, make strong but dry iron. A premium of 20 cents is placed on every 200 pounds in excess, and a fine of 20 cents on every 200 pounds of deficit, on the basis of 1,143 pounds allowed to produce 1,000. A premium of 2 cents is also given for every hectolitre of coal economized below 10 hectolitres per ton.

The finished bars from each furnace are piled and classified: 1, *fibrous;* 2, *metis;* 3, *grained.* The cut pieces are stored away in compartments corresponding to each furnace, with the fracture turned outward to allow of ready inspection. As the men are paid according to the two classes of iron produced, the *inspecteur du puddleage*" makes a note of the quantities of the first and second class iron produced per furnace. This method produces a certain degree of competition among the men, and requires a strict control of the classification.

One steam hammer of 3,300 lbs. is erected for every 10 puddling furnaces, and requires steam at 2½ atmospheres for 10 horse-power. At the new mill a steam hammer of 66,000 lbs. does the work of 6 furnaces, and as each furnace yields 50 balls in 12 hours, 300 balls have to be shingled during this time. One ball takes on an average 45 seconds, so that the 300 balls require 3 hours 45 minutes.

MANUFACTURE OF RAILS.

The quality of pig adopted for rails is No. 6; numbers 1 to 6 represent charcoal iron and merchant bar. The color of each quality is indicated by a letter: A represents gray iron, and H the hardest white. The best quality for rails is termed F, which is white, lamellar, compact, and brilliant, as distinguished from G and H, which are cavernous, and E, which presents a less brilliant, non-radiating, lamellar structure. The quality D is mottled at the centre; C is mottled throughout, and A and B are completely gray. The best pig for rails presents no openings along the edges, and a short, neat fracture. The grains are pretty large and brilliant without. We will describe the composition of the rails of the Paris and Lyons Railroad.

The *piles* for *top and bottom slabs* are 4 ft. long, 7.88 ins. wide and 7 ins. high, made up of 10 layers. The weight is about 385 lbs. Each layer is made of 3 bars with joints crossed; the top and bottom layers are also of 3 bars, the middle one 4 ins. wide, is of grained iron; the remainder is metis iron generally.

The *rail piles* consist of top and bottom slabs, with 7 intermediate plates, 3 of which are ends of rails rerolled. The weight of the top and bottom slabs together is one-third of the total weight of the pile. The contiguous plates are of fine-grained iron to produce a good weld. The remaining layers are of puddled bars and rerolled iron.

The piles for top and bottom slabs are placed 4 together in a reheating furnace; 14 charges are made in 24 hours. The piles are then passed 4 times through the roughing rolls, beginning with the plates edgeways and turning them over 90 deg. at each successive pass. Four passages flat are then made at the finishing rolls. The waste in the furnace is 5 per cent.; 1 fireman and 2 assistants attend to the reheating furnace. The consumption of coal is 5.5 hectolitres per ton of slabs. The slabs are cut to two different lengths, so that the weight of the rail pile can be kept pretty uniform by using a longer or shorter slab.

The rail piles are placed on the hearth of the reheating furnace at points on either side of the doors. They are heated for three-quarters of an hour without change of position, and are then turned over once, beginning at the bridge. After 10 minutes the pile next to the bridge is turned over again and taken to the rolls. The second pile is turned a second time to prevent burning, and the remaining ones are turned over consecutively. To keep the sides of the piles always at the same temperature, the fire is quickened at first at one end of the grate and toward the end at the other end of the grate, so as to change the temperature of the two walls of the furnace. Between each heat, the hearth is levelled down so as to allow

no channels under the piles where the gases would circulate and burn them. The hearth is usually made up of silicious pebbles pulverized. When the piles are taken out they are at a white heat at both ends, but less bright in the middle.

The waste in reheating and rolling the rail piles is 4 per cent., to which must be added a loss, owing to the average rejection of 6 per cent. of the finished rails for flaws, and a loss of 1.06 per cent. from the crop ends; 18 charges are made in 24 hours; 878 lbs. of coal are consumed per furnace in 12 hours. Each furnace is worked by one fireman and one assistant; a second assistant attends to two furnaces at once.

ROLLING OF RAILS.

The roughing rolls are three high. This is essential, as if the plates are not welded at the third groove they will not weld subsequently, being too cold; the passages must then be sufficiently rapid to maintain a welding heat at the third groove. In all, 6 passages are made through the roughing, and 4 through the finishing rolls. In the latter rolls the third and fourth grooves are repeated twice, as they wear out the most rapidly, and the cylinpers could not last the ordinary length of time, *i. e.*, a week without being turned.

In a rail of the following dimensions, height, 5.27 ins.; head, 2.40 ins.; neck, 0.63 ins., the grooves are as follows:

1st groove....neck, 2.71 ins......head, 4.40 ins.
2d groove ....neck, 1.16 ins......head, 3.40 ins.
3d groove ....neck, 0.67 ins......head, 2.61 ins.
4th groove....neck, 0.51 ins......head, 2.36 ins.

The axis of each groove is horizontal, and passes through the middle of the neck, but not of the head, for the first and second grooves, so as to force the iron into the grooves of the "cylindre femelle," Once a week the cylinders are "refreshed" in a lathe, and the grooves turned down to the original sections. The rolls then have only to be brought nearer together. The vertical wear is thus neutralized, but the lateral wear shows itself, especially in the third, or before the last groove. To remedy this, the third groove is made 0.12 inches smaller horizontally than the fourth or finishing groove. The head is rolled flat, until the last groove, when a certain convexity is given; a strong pressure (0.51 in.) is given at the neck so as to force the iron rapidly into the convex space.

From the dimensions above given, for neck and head of last groove, which represents the section of the rail at a dark red heat, and from those of the rail when cold, 0.63 and 2.40, it will be seen that during the cooling the neck and head both expand somewhat, whilst the length only decreases.

The rolls made 60 revolutions per minute for double-headed rails, and 75 for the American form. Their diameters are 19.29, 19.68, and 21.65 ins. The diameter of the upper cylinder is 0.23 in. in excess of the lower one, so that the rail will tend to wind around it and is easier to take hold of when it comes through. A play of 0.078 in. is left between the cylinders.

In the roughening train the differences are still greater. The diameters of the outside rolls differ by 0.67 in., and the middle cylinder has a diameter medium between the two. In the finishing train the male cylinder is chilled, and the female cylinder is cast in sand, so as not to wear out the bearings too rapidly.

FINISHING.

The rails are at once sawed at both ends to the required length, and the rough edges filed down whilst still hot.

When cold they are taken to a shed, straightened, planed and punched. The presses are of two kinds: horizontal, worked by three men; and vertical, worked by two men. A particular machine is also adapted for this purpose, which works with more exactness. The ends are then planed to the right length.

The rails of the Creusot are known for their hardness and perfect weld; their faults are brittleness and unequal lengths. Cinder containing phosphorus has such a marked influence on the brittleness of iron, that one-twelfth or one-thirteenth more phosphorus than usual in the cinder bath was found to make brittle and steely rails.

An English inventor named Jackson has devised a breakwater, consisting of a number of cast-iron tubes fastened together so as to form a sort of honeycomb, which is so placed that the axes of the pipes are parallel with the direction of the most dangerous winds or currents, the waves flowing through the pipe.

EXPLOSIVE AGENTS.*

From "The Journal of the Chemical Society."

The degree of rapidity with which an explosive substance undergoes metamorphosis, as also the nature and results of that metamorphosis, are, in the greater number of instances, susceptible of several modifications by variations of the circumstances under which the conditions essential to chemical change are fulfilled. Gun-cotton furnishes an excellent illustration of the manner in which such modifications may be brought about. If a loose tuft or large mass of gun-cotton wool be inflamed in open air by contact with, or proximity to, some source of heat, the temperature of which is about 135 degs. C. or upwards, it flashes into flame with a rapidity which appears almost instantaneous, the change being attended by a dull explosion, and resulting in the formation of vapors and gaseous products, of which nitrogen-oxides form important constituents. If the gun-cotton be in the form of yarn, thread, woven fabric or paper, the rapidity of its inflammation in open air is reduced in proportion to the compactness of structure or arrangement of the twisted, woven, or pulped material; and if it be converted by pressure into compact masses, solid throughout, the rate of its combustion will be still further reduced. If to a limited surface of gun-cotton, when in the form of a fine thread or of a compactly pressed mass, a source of heat is applied, the temperature of which is sufficiently high to establish the metamorphosis of the substance, but not adequate to inflame the products of that change (carbonic oxide, hydrogen, etc.), the rate of burning is so greatly reduced that the gun-cotton may be said to smoulder without flame; the reason being that the products of change, which consist of gases and vapors, continue, as they escape into air, to abstract the heat developed by the burning gun-cotton so rapidly that it cannot accumulate to an extent sufficient to develop the usual combustion, with flame, of the material.

If, on the contrary, the escape of the gases from burning gun-cotton be retarded, as by enclosing it in an envelope or bag of paper, or in a vessel of which the opening is loosely closed, the escape of heat is impeded until the gases developed can exert sufficient pressure to pass away freely by bursting open the envelope or aperture, and the result of the more or less brief confinement of the gases is a more rapid or violent explosion, and consequently more perfect metamorphosis of the gun-cotton. So, within obvious limits, the explosion of gun-cotton by the application of flame or any highly heated body is more perfect in proportion to the amount of resistance offered in the first instance to the escape of the gases; in other words, in proportion as the strength of the receptacle enclosing the gun-cotton, and the consequent initial pressure developed by the explosion, is increased. Hence, while gun-cotton has been found too rapid or violent in its explosive action when confined in guns, and has proved a most formidable agent of destruction if enclosed in metal shells or other strong receptacles, it has hitherto been found comparatively harmless as an explosive agent if inflamed in open air or only confined in weak receptacles.

Other explosive compounds, and also explosive mixtures, are similarly influenced, though generally not in such various ways, by the circumstances attending their metamorphosis. Thus the rapidity of the explosion of gunpowder is modified by variations in its density and state of division, and in the degree of facility afforded for the escape of the generated gases, and consequently of the heat which is disengaged during the explosion. A charge of gunpowder in an open canister, will explode with more violence if ignited at the bottom than if the spark be applied at the top. The body or mass of the powder in the former case evidently serves to exert a pressure, which is always essential to a violent explosion.

The product of the action of nitric acid upon glycerin, which is known as nitroglycerin or glonoin, appears to be susceptible of only two varieties of decomposition. If a sufficient source of heat be applied to some portion of a mass of this liquid in open air, it will inflame and burn

* An abstract of a paper by F. A. Abel, F.R.S. The original essay by the same Author, is to be found in "Philosophical Transactions" for 1869.

gradually without any explosive effect; and even when nitro-glycerin is confined, the development of its explosive force by the simple application of flame or of other sources of heat, by the ordinary modes of operation, is difficult and very uncertain. But if the substance be submitted to a sudden concussion, such as is produced by a smart though not very violent blow from a hammer upon some rigid surface on which the nitro-glycerin rests, the latter explodes with a sharp detonation, just as is the case with gun-cotton. Only that portion of the explosive agent detonates which is immediately between the two surfaces brought into sudden collision; the confinement of this portion between the hammer and the support, combined with the instantaneous decomposition of the portions struck, prevent any surrounding freely exposed portions from being similarly exploded by the detonation. A similar result is obtained if *any* explosive compound or mixture be submitted to a sufficiently sharp and violent blow, but the tendency of surrounding particles to become inflamed by the detonation is in direct proportion to the rapidity of explosive action of the substances.

The practical difficulties and uncertainty which attend attempts to develop the explosive force of nitro-glycerin by the agency of flame or the simple application of any highly heated body, even when the material is confined in strong receptacles (such as iron shells or firmly tamped blast-holes), appeared fatal to any useful application of the powerful explosive properties of this substance, until M. Alfred Nobel's persevering labors to utilize nitro-glycerin, eventually resulted in the discovery of a method by which the explosive power of the liquid could be developed with tolerable certainty. M. Nobel first employed gunpowder as a vehicle for the application of nitro-glycerin. By impregnating the grains of gunpowder with that liquid, he added considerably to the destruct.ve force of the powder when exploded in the usual way, in closed receptacles. M. Nobel's subsequent endeavors to apply nitro-glycerin *per se* were based upon the belief that its explosion might be effected by raising some portion of a quantity of the liquid to the temperature necessary for its violent decomposition, whereupon an initiative explosion would be produced which would determine the explosion of any quantity of the substance.

I have never suceeded in effecting the *explosion* of nitro-glycerin by simply bringing it into contact with an inflamed or incandescent body, but the following results illustrate the manner in which a score of heat may operate in accomplishing the explosion of this substance.

A piece of very thin platinum-wire, stretched across between the terminals of two insulated copper wires, was immersed in nitro-glycerin. These wires were connected with a Bunsen battery of five large cells, and a second piece of platinum-wire, similar to that immersed in the liquid, was introduced into the circuit. This was then completed, with the intervention of a long piece of platinum-wire between one of the conducting-wires and the battery. The resistance presented by this interposed platinum-wire was gradually reduced by shortening it, until ultimately the short platinum-wire not immersed in the nitro-glycerin was fused. The latter was not exploded nor inflamed, nor was the wire enclosed in it fused, the heat developed in the latter being rapidly absorbed by the surrounding liquid and removed by convection. A very much thicker platinum-wire was now substituted for the thin one, and immersed in the liquid; a second short piece was not interposed in the circuit in this instance, but a long platinum-wire, of the same thickness as the above, was employed, as a means of gradually reducing the resistance in circuit. When the length of this wire had been reduced to five inches, it was raised to bright redness; this state of things was maintained for about one minute, but the short wire in the nitro-glycerin did not glow at the expiration of that period, nor did the liquid exhibit any signs of change, but the glass vessel containing it had become very warm. The long platinum-wire was then removed, and the full battery power was passed into the short wire immersed in the liquid. After the lapse of about one minute the latter began to assume a brownish color (like that of a solution of iron), which rapidly deepened, though no red vapors were perceptible in the upper portion of the vessel, until after the lapse of 90 seconds, when the nitro-glycerin exploded with great violence. Several unsuccessful attempts were afterwards made to explode nitro-glycerin by

means of the electric spark, but eventually, by allowing the sparks from a Ruhmkorff coil with a Leyden jar attached to pass uninterruptedly between the poles, which were just touching the liquid, the latter being splashed up by the discharges, the surface of the liquid speedily darkened, and in 30 seconds it exploded.

It is evident from these results that nitro-glycerin can be *exploded* by electric agency, or by direct application of any other source of heat only, if the intensity of the latter, or the period during which it is applied, suffices to develop decomposition in some portion of the liquid; when once this is established, the temperature is soon raised by accumulation of heat (especially if the application of external heat be continued) until it attains the point at which explosion occurs.

M. Nobel has described various devices for effecting this so-called *initiative* explosion of some portion of a nitro-glycerin charge, of which evidently the most successful are the explosion of a small confined charge of gunpowder, or of a large percussion-cap, when immersed in or placed immediately over the nitro-glycerin. M. Nobel, however, classes these two modes of ignition in which an explosion or detonation is applied as the exploding agency, together with various others in which the simple application of a high temperature to some portions of the nitro-glycerin is proposed as the means of explosion; and although, in his published description of these various methods, he refers to difficulties in developing explosion by those which relate to the simple application of flame or other heated body to the nitro-glycerin, yet he refers the effect produced by the confined charge or the percussion-cap only to the heat developed by the ignition of these exploding agents.

The circumstance that nitro-glycerin, or any preparation of that substance, may be violently exploded *when freely exposed to air*, by the explosion in contact with it of a small confined charge of gunpowder, or of a detonating substance, while other modes of explosion by the application of heat or flame, which have been described by M. Nobel, only develop explosion under special conditions, points to a decided difference between the action of the two modes of ignition, and appears to indicate that it is not simply the heat developed by the chemical change of the gunpowder or detonating powder which determines the explosion of the nitro-glycerin.

An experimental investigation of this subject has left no doubt on my mind that the explosion of nitro-glycerin through the agency of a small detonation is due, at any rate in part, to the mechanical effect of that detonation, and that this effect may operate in exploding the nitroglycerin quite independently of any direct action of the heat disengaged by the gunpowder or other detonating charge.

I was led to examine into this question by an interesting and important observation recently made by my assistant, Mr. E. O. Brown, in connection with gun-cotton. The fact that the violent explosion of this substance cannot be developed except when it is confined in receptacles of some strength, has been up to the present time accepted as indisputable. It occurred, however, to Mr. Brown that as gun-cotton is analogous in its nature and operation as an explosive agent to nitro-glycerin, differing principally from that substance in the rapidity and consequent violence of its explosion, it might also, like nitro-glycerin, be susceptible of violent explosion when unconfined, by being ignited through the agency of detonation. This proved to be the case; for upon exploding a small charge of detonating powder in contact with, or in the immediate vicinity to, compressed gun-cotton freely exposed to air, instead of the latter being simply inflamed and then burning gradually, as would be the case if it were brought into contact with flame or any sufficient source of heat, it explodes with great violence, exerting a destructive action equal to that of nitro-glycerin, and decidedly greater than that produced by gun-cotton when exploded under the conditions hitherto believed to be those most favorable to the full development of its explosive force. The explosion of a small mass of compressed gun-cotton in this manner suffices to determine the similarly violent and apparently simultaneous explosion of small detached masses of the same material, which may indeed be placed at distances of 0.5 to 1 in. from the original source of the explosion or from each other. Thus, rows of detached masses of gun-cotton, placed on the

ground, and extending 4 or 5 ft., have been exploded with most destructive results, by the firing of a small detonating tube in contact with the piece of compressed gun-cotton which formed one extremity of the row or train, the explosion of the entire quantity being apparently instantaneous and equally violent throughout.

In the first experiments instituted with the view of ascertaining the conditions to be fulfilled for insuring the development of the violent action, or for accomplishing the detonation of gun-cotton when perfectly unconfined, the following points were observed:

1. If a confined charge of mercuric fulminate be placed in contact with, or buried in gun-cotton which is in the form of wool or spun-yarn, its explosion does not develop the violent action of the gun-cotton, as would be the case if the latter were in the form of a compact, hard, and homogeneous mass (as obtained by submitting finely divided gun-cotton to powerful pressure). The light and loose gun-cotton is simply scattered with violence; portions of it are sometimes ignited by the flame of the exploding fulminate, the latter result being obtained with greater certainty the less violent the detonation produced by the fulminate charge.

2. The detonation of a small mass of compressed gun-cotton, freely exposed to air, by means of a mercuric fulminate charge, does not accomplish the explosion of light gun-cotton wool or yarn placed in immediate contact with it; the latter is scattered and partially inflamed, as in the preceding case.

3. If the detonation of the fulminate charge which is placed in contact with a mass of compressed gun-cotton is not sufficiently violent or sharp to effect the explosion, the solid mass is shattered and violently dispersed; if the detonation is upon the verge of that required for determining the violent explosion of the gun-cotton, no inflammation of the latter takes place; but if the explosion of the fulminate charge is comparatively feeble, portions of the gun-cotton are inflamed at the moment of dispersion of the mass.

4. Explosive substances which are inferior to mercuric fulminate in the suddenness and consequent momentary violence of their detonation, cannot be relied upon to effect the violent explosion of freely exposed gun-cotton, even if employed in comparatively considerable quantities. Thus, even ordinary percussion-cap composition, which consists of a mixture of mercuric fulminate and potassic chlorate, cannot be used for the detonation of freely exposed gun-cotton, unless a much more considerable amount be used than is necessary of pure mercuric fulminate for that purpose. Many other detonating mixtures, exploding less rapidly and violently than the above, have been tried without success in very considerable quantities, as agents for developing the detonation of gun-cotton in open air.

5. The quantity of confined mercuric fulminate required to effect the detonation of freely exposed gun-cotton, is regulated by the degree to which the sharpness of its explosion is increased by the extent of accumulation of force, consequent upon the strength of envelope in which the fulminate is confined. From 1.3 to 2.0 grms. (20 to 30 grains) are required to detonate the gun-cotton, if the fulminate be confined in a thin case of wood, or in several wrappings of paper, while the same result can be produced with 0.32 grm. (5 grains) if that amount be confined in a cap of thin sheet metal.

If the fulminate be placed in a wide paper cylinder open at the top, which is rested upon the gun-cotton surface, or if it be placed in a heap directly upon the surface of gun-cotton, and if in either instance the violent explosion of the fulminate be effected through the agency of a platinum-wire placed at the *base* of the heap, about 2 grms. (25 to 30 grains) of fulminate will also accomplish the detonation of the gun-cotton, the violent action of the fulminate being, in these instances, developed by the confinement of the portions first ignited in a weak envelope, which consists partly or entirely of the surrounding or superincumbent fulminate.

6. It need perhaps scarcely be stated that the degree of proximity of the detonating charge to the gun-cotton, which is essential for the explosion of the latter, is regulated by the violence of the detonation produced. 0.32 grm. (5 grains) of fulminate inclosed in a metal cap must be placed in a close contact with (*i. e.*, closely surrounded by) the unconfined gun-cotton, in order to effect its explosion, while 1.3 grm. (20 grains), similarly confined, will

produce the same result if placed at least 0.5 inch distant from the surface of the compressed gun-cotton.

The foregoing facts appear to point to the mechanical action of a detonation as as being the real cause of the violent explosion of freely exposed gun-cotton or nitro-glycerin. At any rate they appear to indicate decisively that such explosion is not a result of the direct application of the heat developed by the explosion of the detonating materials. If it were so, then the detonating mixture described as percussion-cap composition, and other explosive mixtures, the ignition of which is attended by much greater development of heat than is obtained by the ignition of pure mercuric fulminate, should explode freely exposed gun-cotton more readily than the latter does; the readiness with which the gun-cotton is exploded should be solely proportionate to the amount of fulminate employed; and gun-cotton should be more readily exploded in the loose and open condition than in the compact and highly compressed form; for the latter presents it in the condition least favorable, and the former that most favorable to ready and rapid ignition by heat. Again, the actual temperature required for the explosion of nitro-glycerin is very considerably higher than the exploding temperature of gun-cotton; the former may be heated to a temperature of 193 deg. C. (380 deg. F.) for some time without exploding, while the latter inflames at a temperature of 150 deg. C., yet a much smaller charge (not more than 0.2 of the amount) of fulminate suffices for the explosion of unconfined nitro-glycerin than is needed for the detonation of gun-cotton. On the other hand, a quantity of confined percussion-cap composition which, if it were pure mercuric fulminate, would be altogether inadequate for the detonation of gun-cotton, suffices for the detonation of nitro-glycerin.

Although the foregoing facts appear to afford indisputable evidence that the direct application of heat, from an exploding charge of detonating powder, is not concerned in developing the violent action of gun-cotton or nitro-glycerin, an attempt has been made to devise some experiments in which the detonation of either of those substances by the agency described should be accomplished in such a manner as to interpose an effectual barrier between the material to be exploded and the heated gases or flame resulting from the ignition of the charge of fulminate destined to furnish the initiative detonation.

Some small pellets of compressed gun-cotton saturated with nitro-glycerin were placed in a cylindrical wooden case open at one end and fixed at the bottom of a trough of water; the air-spaces between the separate pellets were thus occupied by water, the height of which above the charge was about one foot. An electric fuse, primed with 2.6 grms. (40 grains) of mercuric fulminate was weighted and placed at the bottom of the trough, on one side of the cylinder, and at a distance of 2 in. from it. The detonation of the fulminate did not explode the charge; the experiment was then repeated, the water-space which intervened between the fuse and the wooden cylinder being reduced to 1 in. In this instance the firing of the fuse exploded the immersed pellets, the water was projected to a great height, the trough was broken into small fragments, and a crater was formed in the ground upon which it rested. This experiment was repeated with the same results. A small cylinder of compressed gun-cotton saturated with nitro-glycerin, was inclosed in a paper case, which was thickly coated with a gutta-percha and pitch cement. A screen of thin sheet copper was placed at the bottom of a trough, and the water-proofed charge of explosive material was weighted and placed upon one side of the screen at 0.25 in. distance from it. A waterproofed electric fuse primed with 2.6 grms. (40 grains) of mercuric fulminate was placed on the other side of the screen at a distance of 1 in. from the latter; the trough was then filled with water, so that the screen, charge, and fuse were each surrounded and separated by the liquid. In the first experiment, the explosion of the fuse did not affect the charge, but upon repeating the experiment with a fuse placed at a distance of 0.75 in. from the screen, the charge was violently exploded, as in the former experiment.

A precisely similar experiment was tried with cylinders consisting of compressed gun-cotton only, and enveloped in coatings of some thickness of the gutta-percha cement; but even when the charge and the fuse were placed close to the sides of the screen which separated them under

water, the gun-cotton was not exploded by the detonation of the fulminate; the same negative result was obtained when a fuse (enveloped in the waterproof coating) was placed immediately upon a gun-cotton charge enclosed in the paper case and waterproof cement, and exploded under water or in open air. These negative results were instructive, as indicating that the thick yielding envelope which enclosed the gun-cotton charge (possibly assisted by the thin air-cushion by which the enclosed charge was also surrounded) served to protect the comparatively less sensititive explosive material, gun-cotton, by reducing or absorbing the power of the blow or concussion (or whatever the disturbing impulse may be). This explanation was shown to be correct by the fact that a cylinder of gun-cotton, enclosed in a water-tight case of thin sheet metal, and immersed in water, was violently exploded by a fulminate-fuse which was placed by its side, with about 0.25 in. of intervening water.

Some nitro-glycerin, contained in a glass beaker, placed at the bottom of the trough filled with water, was not exploded by a fulminate-fuse, placed at a distance of 2 in. from the side of the beaker; but when the intervening water was reduced to little more than 1 in., the detonation of the fuse exploded the nitro-glycerin.

A 12-pounder cast-iron shell was filled about one-half with small granules of gun-cotton impregnated with nitro-glycerin; it was then filled with water, and a waterproof fulminate-fuse was inserted through the plug which closed the shell. The fuse and each separate granule of the explosive agent were therefore surrounded by water. Upon ignition of the fuse, the shell (which was placed in a very strong room) exploded with a violent report, and was broken into very small fragments, the greater number of which were buried in the timber which lined the cell. A similar shell was half filled with the same explosive agent; the spaces between the granules and the empty portion of the shell were then filled with a thin plaster of Paris mixture, and a fulminate-fuse was imbedded in the solid plaster which filled the upper half of the shell. The explosion of the fuse was attended by a precisely similar result to that obtained in the preceding experiment.

It is believed that these experiments, together with the facts regarding the behavior of gun-cotton which have been stated in the earlier part of this paper, afford convincing proof that the violent explosion of gun-cotton and nitro-glycerin through the agency of a detonating fuse, must be ascribed either to the mechanical effect of that detonating (*i. e.*, to the work done upon the particles more immediately exposed to the blow or concussion of the detonation), or to the development of a disturbance of chemical equilibrium in the explosive agent by the suddenness and peculiar character of the concussion, or by the powerful vibrating impulse which the detonation establishes.

Mr. Joseph Woodward has taken out a patent which may turn out to be of great importance to every iron smelting district in England. The millions of tons of slag running from the blast furnaces, and piled up in such unsightly heaps in all such districts, are to be utilized in the manufacture of the new brick. It is stated that the brick is damp-proof, that it is very solid and firm, without flaw, and pleasing to the eye. The inventor opines that it is likely at once to take the place for ornamentation at present occupied by the costly Staffordshire blue brick. Mr. Woodward's brick can, it seems, be produced so economically, that they can be offered at less per thousand than the ordinary clay and fire bricks.

Europe.—Europe contains 70,718 miles of railway, composed of 150,000,000 cwt. of iron rails, on which 400,000 passenger carriages and 600,000 baggage cars are dragged by 18,000 locomotives, over 52,000 bridges and through 34 miles of tunnels, at the rate of $60,000,000 per annum, with a consumption of 4,000,000 tons of coal.

British Pacific Railroad.—Mr. Waddington has arrived at Ottawa, from London, England, to press upon the attention of the Government the construction of the British Pacific Railway. He believes the best point at which to commence is the mouth of the Neepigon River, on Lake Superior. All the money required for the work can be had in London.

SCREW PILES.

From "The Building News."

It is a fact worthy of notice that although screw piles have been in use in England and the Transatlantic continent for nearly forty years, they have scarcely been employed in France on any scale that warrants a description. This is the more difficult to understand since the value of the principle is universally recognized, and in many situations it would be impossible, in an engineering point of view, to obtain a foundation without them. It is, in fact, only since their introduction, and the establishment of their advantages, that certain structures—light-houses, for example—have been successfully erected on shifting sands, and other kinds of foundations, upon which, by the ordinary methods in use, no superstructure could have ever been erected. On the Bombay, Baroda and Central India Railway screw piles were employed as the means of obtaining a foundation in the numerous rivers crossed by that line. They were screwed down, sometimes by capstan power, at others by yoking native cattle to the end of a long lever, until they came to a firm substratum. Several of these, properly braced together, formed the piers upon which the iron girders were placed, which were nearly all of a uniform span of sixty feet. Unquestionably, one of the chief merits of the screw pile is its great suitability for rapid rivers, which sometimes during a severe drought are nearly dry, and which, in flood time, roll down their waters with all the impetuosity of a mountain torrent. The screw pile not merely fastens itself firmly into the ground, but its comparatively small sectional area offers but little impediment to the motion of the stream. At the same time it must not be forgotten that there are certain descriptions of substrata for which the screw pile is not adapted, and where it becomes necessary to seek a foundation by the employment of other means. We shall allude to this presently. The first application of the screw pile principle was made by the inventor, Mr. Alexander Mitchell, in the harbor of his native town, Belfast, where some buoys were successfully anchored in that manner. The light-houses at Fleetwood and the Maplin sands demonstrated a few years afterwards that the invention was likely to prove of great utility to engineers. The former of these was carried away bodily about a month ago by a schooner which ran into it. It was only the superstructure that fell, the piles remaining in their place. A large number of dock walls, jetties, breakwaters and other engineering works have been erected solely upon foundations secured through the agency of these piles. A brief description of their advantages and suitability for the purposes of foundations will prove of interest to not only our professional readers, but to the amateurs as well.

A screw pile only differs from an ordinary one of timber, or cast or wrought iron, by being furnished at the lower extremity with a screw or spiral. The screw is of particular construction, as it is provided with only two or three turns, or more correctly blades, which are of different diameter. The upper of these has the greatest resistance to contend with, and is therefore of a larger diameter than the others, sometimes reaching the dimension of four feet. The pile being adjusted in either a vertical or inclined plane as required, a movement of rotation is imparted to the upper extremity, and the penetration commences. One of the chief merits in thus obtaining a foundation is, that the pile does not dislodge the earth near and round about it, but bores its own way, so to speak, without disturbing the neighboring layers. Thus fixed in position, the pile can be used either as a mooring post, or as a portion of a pier upon which to erect a bridge, jetty, or other analogous superstructure. The screws are either cylindrical or conical, of cast or wrought iron, and the piles may be also of either material, or of timber. The employment of the latter in connection with the screw end is rare. According to the nature and consistency of the ground to be penetrated, so must the shape and size of the screw be proportioned. If the earth be of a loose, friable, easily penetrable character, a cylindrically formed screw will answer for the purpose; but if it be of a compact, tenacious description it becomes necessary to use a

screw in the shape of a cone. No screw, whatever may be its form and powers of boring, will penetrate into absolute rock, but the principle has been successfully applied in instances where the foundation was a bed of coral. It is manifest that the power required to get the pile down will depend altogether on the nature of the ground to be penetrated. As a rule, a capstan worked by manual labor is found sufficient. One of these machines, with eight bars, about 20 ft. in length, each manned by 5 or 6 laborers, has been found capable of getting down a pile 4 ft. in diameter, to a depth of 15 ft. in an hour and a half, in ground composed of sand, clay, and loose rock of a schistose nature. The conditions being the same, a period of 2 hours was sufficient to sink a screw pile to a depth of 21 ft. In cases where it is not possible to employ the leverage of capstan bars—that is, where room cannot be obtained for erecting a platform—the head of the capstan is furnished with a wheel which can be worked by an endless rope or chain, set in motion by a gang of men. Where the earth is very dry, screw piles can often be "got down" by very simple means. It sometimes suffices to fix to the upper end of the pile a rod with an eye in it to attach a short iron lever, and screw the pile down. This arrangement will only be available for short depths.

The special advantages of screw piles are considered generally to have more relation to bridge foundations, than any other engineering works, but there is another very important application of the principle which we have as yet only touched upon. It relates to the anchorage of buoys and mooring posts for vessels. Obviously the desideratum in this particular class of works is that the hold or grip of the anchor should be a maximum. In other words, what kind of anchor will give the greatest resistance to a tensile strain, tending to cause it to drag, the anchor itself being of the least weight?

It is a simple question of a combination of maximum hold with maximum weight. About twenty years ago some highly interesting and instructive experiments were undertaken with a view to the practical elucidation of this important point. Some of the best-made anchors, weighing 2 cwt., were dragged along the ground, by a force which produced no effect upon a screwed mooring, inserted to a depth of 3 ft., and weighing only 8 lbs. Others weighing 7 lbs. resisted hauling better than anchors having a weight of nearly 5 cwt. The value of screw piles and moorings for light-house, jetties, breakwaters, and floating signals, and all structures exposed to violent hurricanes and sudden impactive forces, can scarcely be overestimated. On this account they would be found very useful in stormy latitudes, for securely fixing telegraph posts, as it is the commonest occurrence in the world to hear of the telegraphic communication being interrupted in consequence of the posts being blown down. There is one more point relating to screw piles that deserves mention, although probably it is seldom brought into notice. It is the facility with which they can be "drawn." All that is necessary to accomplish this task, which with piles of a different description is a very tedious and laborious one, is to reverse the operation of getting them down—in a word, to unscrew them. It might be stated that when a pile is once down, it is not intended ever to come up again. This assertion is not quite correct, even for permanent works, and certainly incorrect when temporary works are considered. Piles are sometimes required to be drawn in situations when it has been thought that they were down "for good." In works of a temporary nature, where the piles are of timber, they are seldom permitted to be drawn, as the operation would distnrb the foundations of the permanent structure, but are cut off near the ground level. If screw piles were employed in temporary dams and such like work, they might be drawn, as the unscrewing would scarcely affect the ground in any sense, and their comparatively small sectional area would still more lessen the chance of any danger. The piles might thus be used over and over again, and constitute a regular item of the contractor's plant. Perhaps the only description of ground that would be unsuitable to the use of these piles would be a stiff clay. The screw would get clogged, and the labor of getting it down would be more than what would compensate the other advantages. Hollow cylinders would be the proper substitute to employ in such a case.

ESTIMATING EARTHWORKS*

By MR. JOHN R. GILLISS.

It is often desirable to make approximate estimates directly from a profile or longitudinal section when lack of time or better data prevent the use of more exact methods. To expedite and increase the accuracy of this work, the following method has been devised :

The ordinary earthwork tables show for any given road bed, or side slope, the quantities in 100 ft. for each foot in height, assuming the ground level transversely. We may take any one of these tables and plot it as a curve, by drawing a horizontal and vertical line, plotting the heights vertically on the same scale as vertical scale of profile or section on which it is to be used, and the quantities horizontally on an assumed scale. 1,000 cubic yards per inch will be found convenient for most work. The diagram is then copied on tracing cloth or horn, and is ready for use.

To get the amount of work between any two stations on a profile or section, lay the diagram so that its horizontal line is parallel to those of the profile, and bisects the grade line at a point ; then move it horizontally until the curve passes through some point, which averages the surface line. It is evident that the distance will scale the cubic yards in the prism.

The quantities thus obtained might be read off separately for each hundred feet, by having a scale on the diagram, but there is a much better way. The measuring wheel is simply a wheel about $\frac{3}{4}$ in. in diameter, with a milled edge and turning on a screw. It is mounted in a frame with a straight edge in front to serve as an index. It may be started from either end of the screw, and after measuring any distance, if run in the opposite direction over a scale, will stop when it gets back to the end of the screw it started from, showing the exact distance it had traversed. On this wheel the quantities due to each hundred feet or successive distances are added, and as often as desirable it is run over a scale, the total number of yards noted, and a fresh start made. A wheel, such as that described, will hold about 75,000 yards on the scale assumed.

Having thus given an outline of the process, the details will be more intelligible.

The diagrams for quantities on side-hill work require tables especially calculated for them, showing the cubic yards due to varying heights for each 5 or 10 deg. of transverse slope, as shown below. The curves thus obtained, and due to different transverse slopes, may for any given road, bed, and side slope, be plotted in a single diagram. This enables us to interpolate any intermediate slope by the eye. It will be noticed that both formulæ and diagrams curve the case of side cuts where it is fill on the centre line, and conversely. This is shown in the formulæ by the quantities having a + value for any value of h greater than—b × : and in the diagrams by the curves starting above the horizontal line where the ground slopes transversely and intersecting it at some distance from the origin. To prevent the diagrams from being too long and unwieldly, the curves may be doubled back upon themselves.

If on tracing cloth or paper, the diagrams should be pasted on the back of a rectangular frame of pasteboard or tin ; if the latter is used it can be turned up at the edge, and will then be less apt to catch against joints in the paper. The left-hand edge of opening in frame should exactly coincide with vertical line of diagram, that it may serve to stop index of measuring wheel.

The scale for light work where none of the cuts or fills are over 30 ft. may be 400 yards per inch, but when work has places 50 or 60 ft. deep, the diagrams would be too long, and 1,000 yards per square inch more convenient. The scale had best be plotted in the centre of a long strip of paper and laid on the edge of the table when in use.

Similar diagrams can be obtained for culverts, retaining walls and trestles. Box and arch culverts will give straight lines; earthwork, open culverts, and retaining walls will be parabolas with their axes above the horizontal line, and trestles, a series of disconnected straight lines with a break in their continuity at each story in height.

Irregularities in surface line between

*Paper read before the American Society of Civil Engineers, p ril 21, 1869.

two stations can be readily averaged by the eye.

Since the diagrams can be plotted with more accuracy than is generally given to the profile or section, the errors will be principally those arising from imperfections in the latter. The method being one of *mean heights* gives results a little too small. If instead of taking the weights at points half way between consecutive stations, they were taken at even stations, only half the quantity due to first and last station being allowed, the result would be by means of end areas, and therefore too large. The greatest uncertainty arises in assuming the transverse slope where it has not been measured on the ground; this must occur in any method.

These diagrams will be found most useful in balancing cuts and fills, whether it be by alterations of grade on a line already run, or by altering the line when running to a fixed grade, and for making approximate estimates. From 3 to 15 minutes are required to estimate and classify the work per mile. The addition being purely mechanical, it may be carried on for hours without fatigue.

This process may be considered a new method of mechanical integration, and with slight modification will give areas, centres of gravity, and of inertia, etc. Among its applications is the determination of transverse strength of beams of irregular form.

FORMULÆ FOR EARTHWORK TABLES.

Areas.

Let B H F D be the cross section of a cut, and let

$HF=2b$, $CG=h$, $BI=C_1$, $DE=C$, $\cot. DFE=\frac{FE}{DE}=s$, $\tan. BAI=\frac{BI}{AI}=t$, then $cs+b+\frac{h}{t}=\frac{c}{t}$ $\therefore c(1-st)=bt+h$ $\therefore c=\frac{bt+h}{1-st}$ $\therefore ADF=\frac{b+\frac{h}{t}}{2}\left(\frac{bt+h}{1-st}\right)=\frac{(bt+h)^2}{2(t-st)^2}$. . . . . . (1)

$c_1 s+\frac{c_1}{t}=\frac{h}{t}-b$ $\therefore c_1(1+st)=h-bt$ $\therefore c_1=\frac{h-bt}{1+st}$

$$\therefore ABH=\frac{\frac{h}{t}-b}{2}\left(\frac{h-bt}{1+st}\right)=\frac{(h-bt)^2}{2(t+t\,s^2)}. \quad . \quad (2)$$

$$\therefore BHFD=\frac{(h+bt)^2}{2(t-st^2)}-\frac{(h-bt)^2}{2(t+st^2)}=$$

$$\frac{h^2 s+2bh+b^2 st^2}{1-s^2t^2}. \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Cubic Yards in 100 *Feet.*

Ground level from (3) $t=o$

$$Q^1=\frac{100}{27}(h^2 s+2bh).$$

Side cut from (1) h between $+bt$ and b

$$Q^{11}=\frac{50}{27(t-t^2 s)}(bt+h)^2.$$

Thorough cut from (3) h greater than $+bt$

$$Q^{111}=\frac{Q^1+\frac{100}{27}b^2 st^2}{1-s^2t^2}.$$

In these equations, after assigning values to b, t, and s, the only independent variable will be h, and since it only enters in its first and second powers, the second difference will be constant, and furnish the most rapid and accurate means of calculating the tables.

Let n be the interval between successive values of h, whose corresponding second difference is required. Giving h an increment n in Q^1, and then subtracting Q^1, we get

$$\triangle Q^1=\frac{100}{27}\{(h+n)^2 s+2b(h+n)-h^2 s-bh\}$$

$$=\frac{100}{27}(2hns+n^2 s+2bn)$$

$$\triangle Q^1=\frac{100}{27}\{(h+2n)^2 s+2b(h+2n)-(h+n)^2 s-2b(h+n)\}=\frac{100}{27}(2hns+3n^2 s+2bn)$$

$$\therefore \triangle^2 Q^1=\frac{100}{27}(2n^2 s);$$

In a similar manner we get

$$\triangle^2 Q^{11}=\frac{100\,n^2}{27(t-t^2 s)}$$

$$\triangle^2 Q^{111}=\frac{200\,n^2 s}{27(1-s^2t^2)}$$

It is generally unnecessary to calculate the quantities oftener than every 5 ft. after the first five, as the curves become so near straight lines that they can be filled in mechanically.

In cases where it is considered sufficiently accurate to assume the ground level transversely, the foregoing process may be very much simplified.

Assume width of road-bed zero, the side slopes meeting at G. Then let

$BE=h_1$, $EG=h_1$, $BG=h$, and $\frac{BC}{BG}=S$.

$$\therefore ACG=h^2 s.$$

The following table will give cubic yards in 100 ft. for $S=1$.

h.	Q.	h.	Q.	h.	Q.
1′	3.70	10′	370.37	55′	11203.70
2	14.81	15	833.33	60	13333.33
3	33.33	20	1481.48	65	15648.15
4	59.26	25	2314.81	70	18148.15
5	92.59	30	3333.33	75	20833 33
6	133.33	35	4537.04	80	23703.70
7	181.48	40	5925.93	85	26759.26
8	237.04	45	7500.00	90	30000.00
9	300.00	50	9259.26	95	33425.93

The above quantities have only to be multiplied by the ratio S for any other side slopes. Or, if plotted as a curve O A, the curves O B, O C, corresponding to any other side slopes, may be laid off from O G with proportional dividers.

For any width of base, F D = 26, we have only to add h_{11} to the given height h_1, calculate the total area A C G, and subtract area F D G.

$$\text{Cubic yards in 100 ft. of F D G} = V = \frac{100}{27} h_1, b.$$

When b is constant, this is the equation of a straight line O D. The co-ordinates O F, O E, of its intersection O, with any curve O A, represent, respectively, the height h_1, and cubic yards V. If we move the origin of co-ordinates to O, the result will evidently be the same as adding h^1 to height and subtracting V from cubic yards due to sum of heights. We, therefore, have the following simple formulæ:

$$Q = \frac{100}{27} h^2 S, \text{ and } V = \frac{100}{27} h_1, b.$$

The first represents a series of parabolas, one for each side slope, with a common axis and vertex. The second represents a series of straight lines radiating from that vertex, one for each width of road-bed. The intersections of these lines give the new origins from which curves corresponding to any side slope and width of road-bed can be traced.

The preceding method was devised in 1866 to make an estimate on 200 miles of light work on the Central Pacific Railroad.

RAILROAD BUILDING.

From "The New York World."

The recuperating energy and capital of the country are turning into the construction of new railroads, and the extension and perfection of the older lines. Scarcely a corporation now in existence that is not planning or carrying out some project for adding to its business. Among the more prominent of the lines now contemplated or building, are, beginning at the eastward, a line to unite Portland to Halifax, so as to form a part of the short ocean ferry to Europe. Portland is also seeking a direct connection with the lakes and the Mississippi system of roads by way of Ogdensburgh. Massachusetts has her great central line, intended to tap the New York lines by passing through the Hoosac tunnel, and also by the Hartford & Erie, now nearly completed. Connecticut is rapidly completing a new and a shorter line between New York and Boston by the Willimantic link. New York State is building a great line to Oswego—the Midland Railway, which will open up a portion of the State too long neglected. The Southern Central and Long Island Railways are reported to be making fair progress. New Jersey, although her Legislature has narrowly refused the charter for the Air Line road between Philadelphia and New York, has nevertheless, another route to Philadelphia in prospect by an extension of the New Jersey Southern (formerly Britain and Delaware) Railroad from its present terminus at Port Monmouth to a junction with the Newark and New York road at the former place. Pennsylvania is engaged in building several little local roads mainly to reach her coal and iron deposits. At the same time her great Central Railroad Company has finally succeeded in obtaining control of Western connections to Erie, Cleveland, Chicago, Cincinnati, Louisville, and St. Louis, so as to present at this moment the most colossal and formidable railway consolidation in the country, or perhaps in the world. Maryland and Delaware are pushing a line down the eastern shore of the Chesapeake Bay, so as to establish another through line to the South. Virginia has relinquished her state interests in the Chesapeake & Ohio road, and a strong party of New York capitalists are

now pushing forward that line to the Ohio River, which will, within two years, establish a short line between the lower Ohio Valley and the Atlantic ports. Connecting with it are a line from Gordonsville to a point on the Potomac below Alexandria, another from Newport News to Richmond, and a third from Lynchburg to Covington. This activity in Virginia is cheering for the future of that State, and it will be instructive to note which of the candidates for the coming city of Chesapeake—Newport News, Norfolk, West Point, or Acquia Creek—shall first secure a line of ocean steamers for itself. Further south numerous lines are in progress, which is one of the best indications of returning prosperity in that impoverished section. Georgia has its Brunswick and Albany road under way; Florida its Central Railroad projected; Alabama its lines to Chattanooga on the north, and to New Orleans on the west; Louisiana is pushing her line from Brazos to the Texan frontier. In Northern Texas and Arkansas the Memphis and El Paso is making fair progress. Kentucky has a great central line partially constructed to unite Columbus, at her western extremity, with Cattellsburg, at her eastern border, passing through Elizabethtown and Lexington, which, in unison with the Chesapeake & Ohio through West Virginia, will constitute the grand line between the Southwest States and the national capital. Along this central belt are several other lines more or less interwoven with the foregoing; for example: Ohio has a line in contemplation cutting obliquely across her territory from Toledo to the iron and coal regions near Pomeroy; another to connect Cincinnati with Portsmouth, called the Cincinnati & Chesapeake. Indiana, which is already checkered with roads, has an important line constructed from her territorial centre to the central city of Illinois, known as the Indiana and Illinois Central road, begun before the war. Also a short line from Terre Haute to St. Louis. In Illinois, both Chicago and St. Louis are pushing lines down to the Ohio River, so as to tap the rich regions of Western Kentucky and Middle Tennessee; the Chicago & Vincennes being the project of the former city, and the St. Louis & St. Joseph westerly, as the protegé of the latter. Both roads pass through coal fields. Connected with this same belt of new lines reaching from the Potomac to the Mississippi are extensions in Missouri. The St. Louis & St. Joseph and the St. Joseph & Denver form the two essential links in the chain of direct railroad communication to the far West, which, by avoiding the circuitous route from Omaha, will have a great advantage hereafter, as the Union Pacific Company cannot, by its charter, discriminate against any of its Eastern connections, receiving the Government subsidies. Iowa and Minnesota are being gridironed by new roads. In Nebraska and far-distant California and Oregon, new roads are building with extraordinary rapidity also.

The inference to be drawn from this general activity is a flattering one. It takes money to build railroads, and surplus capital, instead of venturing against the risks of commercial business, or the still greater dangers of real estate inflation, is in large part turning to the improvement of our great system of railroad communication. These roads are built in part upon mortgage bonds, which are based upon pledges of the property. Though these railroad bonds are placed in the hands of Wall street bankers for sale, dealings in them are not to be confounded with the ordinary stock-gamblings of that locality. Railroad bonds differ in that regard from railroad stocks, although both are liabilities of the railroad corporations; the bonds have to be taken care of, though the stock may be neglected. Even the most recklessly managed roads have generally so scrupulously provided for their bonds that they are accounted as safe and convenient for permanent investments as liens on real estate.

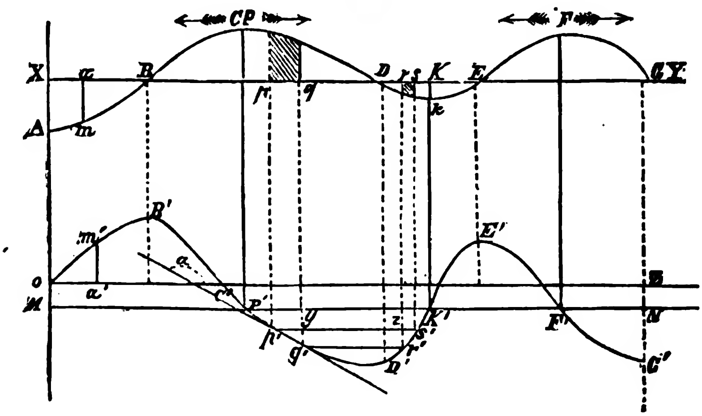
Wire-rope Tramways.—It appears that the method of transport by wire-ropes, which was tried on an experimental line near Leicester last year, has made considerable progress since that time. Thirteen lines, varying from short distances to 4 miles in length, have been constructed, and upwards of 100 miles are in course of preparation or under contract.

Six thousand nine hundred workmen at the iron and steel works at Krupp, in Germany, produced 125,000,000 lbs. of steel last year.

CUTTING AND FILLING.

From the "Polyt. Tiddschrift de Christiana," through "Annales du Génie Civil."

The profile of the road is represented by A, B, C, D, E, F, G, ; $X\ Y$ is the grade line. Take an arbitrary axis, $O\ Z$, parallel to $X\ Y$ and lay off upon it as ordinates masses of earth, then the ordinate $a'm'$ will represent the quantity of earth needed for filling between the profile $A\ X$ and $a\ m$; the ordinate B' representing the filling between the profiles $A\ X$ and B. Considering the fillings as positive and the cuttings as negative, it is obvious that the ordinates increase as long as there are fillings ; that is to B, and begin to diminish when cutting is necessary. At the point C the ordinate is zero, for cutting and filling are equal. When there is more cutting the ordinates become negative, and reach a maximum at D', where filling begins again. In this way we obtain a curve $O\ B'\ C'\ G'$. Regarding a part $p'q'$ as a straight line, and denoting by a the angle formed by $p'\ q'$ with the axis, we have tan. $a = \frac{M}{l}$; M being the cutting between p and q and l the distance $p\ q$. As a is obtuse, tan. a is negative, which shows that M is a cutting. If the distance $p\ q$ is very small, a is the angle between the tangent and the axis, and the greater the value of tan. a, the greater the mass of cutting or filling at the point under consideration. If the profile of the road is constant, the curve becomes a straight line.



Draw an arbitrary line $M\ N$, and let $P'\ K'\ F'$ be the points of intersection of the line with the curve. These points show how the earth should be moved so that cuttings and fillings may balance. The cutting between P and D is of exactly the same volume as the filling between D and K. $P\ D$ can therefore be moved to $D\ K$. So the mass between the profiles F and E corresponds exactly to the cutting between E and K. At the extremities there would doubtless be a difference between the two, so that different methods are required here. The line $M\ N$ which fixes the points to which the earth should be moved is called the line of level (*ligne de niveau.*)

The surface between the curve of cutting and the line of level represents the product of the mass of earth to be moved by the distance of transportation.

Consider, for example, the earth between two adjacent profiles p and q ; this strip is represented by $y\ q'$. Draw $p's'$, $q'r'$ parallel to the axes ; then $z\ r' = y\ q'$; and $z\ r'$ represents the mass $r\ s$ of filling ; $p\ q$ can then be used to fill $r\ s$ and is carried to $p's'$. The surface $p's'r'q'$ represents the product of the mass $p\ q$ by its distance ; and as this holds for all parts between P and K, the surface $P'\ K'\ D'$ corresponds to the product of the mass to be carried from $P\ D$ to $D\ K$ by its distance. As the expenses of transport are proportional to the product of masses by distances, these will be proportional to the surfaces between the line of level and the curve of filling.

If an exact expression of the cost of transport is desired it can be put under the form :

$$K = I a M + \Sigma e \triangle M$$

in which a and b are constants depending on the kind of transportation, M is the mass of earth to be moved, and e the distance. As M is constant, $\Sigma e \triangle M$ is the variable which represents the surface of the curve.

If the expense is to be a minimum, then $\Sigma e \triangle M$ must be the least possible. The problem is equivalent to this ; to draw the line $M N$ so that the surface shall be a minimum: Draw a new line of level $O Z$ at a distance $\triangle x$ from the first ; let $M P' = l_1$, $P' K' = l_2$, $K' F' = l_3$, $F' G' = l_4$; $F =$ total surface ; then

$$F + \triangle F = F + \triangle + (l_2 + l_4 - l_1 - l_3).$$

In order that F may be a minimum it is necessary that $\triangle F = O$, hence $l_2 + l_4 = l_1 + l_3$. The parts of the line above the mean line should be equal to those below.

EXHAUST STEAM FOR HEATING PURPOSES.

By CHARLES E. EMERY.

From "The American Artisan."

Questions are frequently asked regarding the relative economy of heating buildings with live steam taken direct from the boiler, or with the exhaust steam from a non-condensing engine.

Though the steam-engine is a *heat* engine, the best examples utilize only 10 per cent. of the heat in the steam used, consequently at least 90 per cent. of the heat which enters the cylinder escapes with the exhausting steam, and can be made available in no way except for heating purposes.

The temperature of the exhaust steam from a condensing engine is from 130 to 140 degs. Fahr., and that from a non-condensing engine is from 212 to 220 degs. and upward, varing according to the amount of back pressure in either case. A portion of the escaping heat is generally utilized in heating the feed-water for the boiler. In the condensing engine the low temperature of the exhaust steam and the liability to air leakages and loss of vacuum in long pipes, make it impracticable to save any more of the heat than that mentioned, and the remainder is necessarily wasted in heating the condensing water. In the non-condensing engine there is on the average 10 per cent. of the heat utilized by the use of a feed-water heater, in addition to the 10 per cent. transmuted into work, conseqently 80 per cent. of the original amount of heat remains in the exhaust steam and is usually wasted in the atmosphere. If this large quantity could be used for heating buildings without interfering with the performance of the engine, there would be no doubt of the value of the system—the heat in fact would cost nothing; but it is evident that in order to cause this steam to traverse through heating-pipes and coils it must have sufficient pressure in excess of that of the atmosphere to enable it to overcome the increased resistance. The additional pressure varies from 2 to 5 lbs. and upwards per sq. in., and acts as so much back pressure upon the piston, thereby reducing the power of the engine. The power lost must be supplied by increasing the mean pressure upon the driving side of the piston, and the question becomes: What is the relative cost in fuel of supplying the heating-pipes with steam direct from the boiler, as compared with that required for the extra power necessary to circulate the exhaust steam through the building?

The answer to this problem depends upon the particular circumstances of each case, and to make the subject generally understood, it is first necessary to investigate some of the known facts in regard to low-pressure steam-heating apparatus.

Manufactories where steam-power is employed generally have a large number of windows for the convenience of the workmen, and are often more or less exposed to cold draughts from hoistways, staircases, and outer doors; and though the temperature need not be so high as in dwelling-houses, it would be unsafe to allow less than one square foot of heating surface in the heating-pipes and coils to every one hundred cubic feet of space to

be heated. In order to form a safe estimate of the amount of fuel required when the steam is taken direct from the boiler, we may assume as an extreme case that the difference between the external air and that of the room is to be 69 degs.; then, according to the experiments and formula of Tredgold, we find that it will require $3\frac{1}{8}$ sq. ft. of surface to condense a pound of steam per hour, and if 1 lb. of coal evaporate 8 lbs., of water, it will supply steam to ($8\times3.125=$) 25 sq. ft. of heating surface, and will heat ($25\times100=$) 2,500 cubic ft. of space for one hour. The estimate will be correct for average circumstances, but will not apply to all cases of low-pressure steam-heating, especially where the rooms are unusually exposed either to draughts of air or great extremes of temperature.

The cost of heating by exhaust steam may be measured by the amount of coal required to produce the power necessary to overcome the increased back pressure. We have seen that in ordinary cases 1 lb. of coal per hour will heat 2,500 cubic ft. of space. If, therefore, in a given instance, 3 lbs. of coal are required per horse-power per hour, then for every horse-power expended in distributing the exhaust steam through the building, there should be at least three times 2,500, or 7,500 cubic ft. of space heated.

In estimating the greatest amount of space that can be heated by the exhaust steam of an engine, it should be borne in mind that the quantity of steam discharged necessarily varies with the work being done, and as the temperature of the building requires to be constant, we can only utilize the quantity of heat escaping when the engine is lightly loaded. For instance, an engine of 80 horse-power may be loaded occasionally to only 40 horse-power for half an hour or more at a time. If each horse-power require on the average 3 lbs. of coal per hour, 40 horse-power will require 120 lbs. As has been before mentioned, the exhaust steam from an engine contains $\frac{8}{10}$ of the heat received from the fuel, so in the present case the maximum heating effect is equal to $\frac{8}{10}$ of 120 lbs., or 96 lbs. of coal per hour; and as each pound of coal will heat 2,500 cubic ft. of space, 95 lbs. will heat 240,000 cubic ft., equal to the capacity of a building 100 ft. long, 60 ft. wide, and 40 ft. high. The extra power required to overcome the back pressure in that sized engine could not well exceed 10 horse-power, which would cost 30 lbs. of coal per hour; and as 96 lbs. would be required were steam taken direct from the boiler, the saving is ($96-30=$) 66 lbs. per hour, or 68 per cent. If the quantity of space heated be less than that mentioned, the percentage of saving will be less; for instance, to heat 150,000 ft. of space in the ordinary way would require 60 lbs. of coal per hour; but with the exhaust steam in the above instance the cost will still be 30 lbs., so the saving will be 50 per cent. In warm days in winter, when less heat is required in the buildings, the same power will be taken from the engine to supply the less quantity of heat, so that the percentage of saving will be less. There would be some saving, however, whenever it required more than 30 lbs. of coal to heat the rooms. In case each horse-power required more coal per hour than that stated, the advantages of exhaust heating would be correspondingly diminished, unless the size of the engine and amount of power necessary to distribute the steam were also less. In some instances, probably, the system is productive of loss as compared with the use of live steam, so the true plan is to make accurate calculations in each case. The following directions may therefore assist many readers:

To ascertain whether heating by exhaust steam is economical where it has already been applied, the first step is to measure the extra back pressure on the piston, which can be done by indicating the engine when the steam is escaping freely into the atmosphere, and when the exhaust is throttled for heating purposes, and comparing the back pressures shown by the diagrams. If this be not convenient, one leg of an inverted glass siphon containing mercury may be connected to some enlargement of the exhaust-pipe, and the mean difference in level noted in the two cases the same as before. One pound pressure corresponds to about 2 (2.037) in. of mercury. A longer siphon filled with water may be used with some inconveniences. In such cases, 1 lb. pressure corresponds to a column of water 2.3 ft. high and 60 deg. temperature, or 2.4 ft. high at a temperature of 205 deg.

Having ascertained the extra back pressure, the horse-power required to overcome it may be ascertained by the follow-

ing rule, viz.: Multiply together the back pressure, the area of the piston in square inches, and the speed of piston in feet per minute, and divide the product by 33,000.*

The next step is to ascertain the coal required per horse-power per hour. This should be done, when practicable, by regular experiment. In other cases, it may be assumed that engines working with a steam pressure of 50 lbs. and under, with little expansion will require 5 to 6 lbs. of coal per horse-power per hour. With more expansion, 4 to to 5 lbs. will be required; and the most improved form of expansive engines, working with steam at 80 lbs. pressure, will furnish a horse-power for 3 lbs. of coal per hour. By multiplying the horse-power due to the increased back pressure by the coal required per horse-power per hour, and the product by 2,500, the result will be the least number of cubic feet of space which can be heated economically by the exhaust steam from that engine. The advantages under different circumstances may be ascertained in the manner previously stated.

In heating a building by exhaust steam particular attention should be given to the size and arrangement of the pipes. A main exhaust pipe should be run up through the building and out of the roof in a usual manner. This pipe should be larger than is ordinarly employed, so as to form a kind of expansion chamber to equalize the exhaust pressure. In summer, the top of this pipe should be open, but in winter it should be covered with a flat valve faced with wood or rubber, fitted so that it can be moved with little friction, and weighted to the pressure required to circulate the exhaust steam, which will usually be less than 3 lbs. per sq. in. This vertical pipe may be made of cast-iron, and the ordinary socket joints with lead filling will answer, provided care be taken to sustain the weight of the pipe wholly at the bottom, so that all other parts are free to expand upward when heated, at the rate of one-eighth of an inch to every 8 ft. in length. From the vertical exhaust pipe the heating pipes may be led out for each floor of the building. A common plan is to put a good-sized cast-iron pipe under the work-benches along the sides of the rooms. Such pipes should be connected by bolted flanges, and ample provision made for expansion and contraction. Heating coils of the ordinary construction may also be used, care being taken to make the leading pipes wiih as few bends as possible and of sufficient size. To obtain the proper size of pipe for a given case, the following formula may be used, which is founded on some experiments made by the writer for the United States Government, viz.: $a = W \div 46\ (p + 3)$ in which $a =$ area of steam-pipe in square inches, W the weight of steam in pounds delivered per hour, and p the difference in pressure. Assuming as an extreme that 2.4 sq. ft. of surface (s) will condense 1 lb. of exhaust steam per hour, then, when the difference in pressure equals 1 lb., $a = s \div 440$. The following is then a safe rule:—Divide the heating surface in square feet by 400, the result is the proper area of the pipe in square inches. The following table gives the amount of surface which will be supplied with steam through pipes of the sizes mentioned:

DIAMETER OF PIPE.	AMOUNT OF SURFACE.
⅜ inch	40 square feet
½ "	75 "
¾ "	170 "
1 "	300 "
1¼ inches	480 "
1½ "	700 "
2 "	1200 "
2½ "	1900 "
3 "	2800 "

The pipes should be slightly inclined so that the condensed water will move in the same direction as the steam. The ends of the various heating-pipes and coils should be connected with a water-pipe terminating near the boiler in an inverted siphon, the shorter leg of which should be about 7 ft. long. The bend may extend under ground if necessary. This siphon should deliver the condensed water into a tank where it can be returned to the boiler. An air-cock should be placed in the water-pipe to allow the air to escape in starting.

Arrangements should be made so that the exhaust steam can be shut off from each room separately by a valve, and in

* Many engineers will find the following formula more convenient.

$$\text{H. P.} = \frac{d^2 srp}{252{,}000}$$

which, put in the form of a rule is: Horse-power equals the square of the diameter (d) in inches, multiplied by the length of a single stroke (s) in inches, multiplied by the number of revolutions per minute (r), multiplied by the extra back pressure (p), and divided by 252,000.

some instances it may be desirable to admit live steam into portions of the pipes when the engine is not in motion.

It is believed that the system of heating by exhaust steam may be applied with advantage in nearly every establishment where a non-condensing steam-engine is in use.

THE FAIRLIE ENGINE TRIALS.

From "Engineering."

The following details of experiment with the Fairlie engines, "Progress" and "Little Wonder," upon the Mid-Wales Railway, and the 1 ft. 11½ in. Festiniog line, will be found of interest, and go to prove all that we have advanced in favor of the system. The performance of the engines must have satisfied the members of the Imperial Russian Commission who were present, of their value, especially upon steep gradient lines, with sharp curves, such as those on the Festiniog Railway.

THE FAIRLIE ENGINE ON A 1 FT. 11½ IN. GAUGE, COMMONLY CALLED 2 FT.

The Result of Experiments on the Festiniog Railway, on February 11 and 12, 1870.

Feb. 11.—Started from Portmadoc with the "Little Wonder," or Fairlie engine and

	tons.	cwt.	qrs.
90 slate wagons	57	10	0
7 passenger carriages and vans	13	10	0
57 passengers	4	0	0
	75	0	0
Engine	19	10	0
	94	10	0

Engine, double bogie, $8\frac{5}{16}$ in. cylinders × 13 in. stroke.
Wheels, 2 ft. 4 in. diameter.
Pressure of steam, average 150 lbs.
Steepest gradient, 1 in 74.
Sharpest curves, 1¾ chains.

The total wheel base is 19 ft., the wheel base of each bogie is 5 ft., and the total length over all, 27 ft.

On sharpest curves and steepest gradients, with engine in full gear, average speed 14½ miles, exclusive of time lost in stopping and starting. Length of train, 854 ft.

Generally observed that, even on curves of 1¾ chains radius and at maximum speed, there was very little perceptible oscillation or movement on the engine, or in the carriages, and by no means such as is usually felt, even on comparatively easy curves on ordinary railways, and less at high speed than at low speed. The superelevation of the outer rail on the sharpest curves was 3 in.

February 12.—Experiments with "Little Wonder," 19½ tons; "Welsh Pony," 10 tons; "Mountaineer," 8 tons, to test steadiness of running on Frath Mawr Embankment.

On the "Welsh Pony" and "Mountaineer" strong vertical oscillation with less lateral oscillation.

On the "Little Wonder, when riding on the footplates, no perceptible vertical or lateral oscillation, but a smooth floating movement when riding on the bogie frames, slight lateral oscillation, but less than on the other engines.

The oscillation of the Fairlie engine being confined to the bogie, the influence of impact on the rails from the flanges of the wheel was far less than in the case of the "Pony" or "Mountaineer," the whole weight of these engines being brought to bear in the course of their oscillations upon the rails.

In all the above cases the speed was confined to 10 or 12 miles an hour on a straight line on a gradient of 1 in 1,200, and the line was laid with rails weighing only 30 lbs. to the yard, not fished at the joints.

The "Welsh Pony" engine, weighing 10 tons, with cylinders 8⅜ in. diameter, by 12 in. stroke, and with wheels 2 in. diameter, took 50 wagons loaded with slate from Portmadoc to the engine house, and stopped on a gradient of 1 in 85, unable to proceed further with 160 lbs. to the square inch of pressure:

	tons.	cwt.	qrs.
Weight of 50 wagons loaded	123	10	0
Passengers	3	10	0
	127	0	0
Engine	10	0	0
	137	0	0
The "Welsh Pony" then took 25 wagons weighing	59	7	2
Passengers	3	10	0
	62	17	2
Engine	10	0	0
	72	17	2

and mounted 1 in 85 with 140 lbs. pressure of steam in starting, and 130 lbs. after running about ¼ of a mile, when she was stopped to return.

The same engine then tried with 30 wagons could not start on a gradient of 1 in 85, but the engine wheels did not revolve there; there was, therefore, no want of adhesion. The load having been reduced to

	tons.	cwt.	qrs.
26 wagons weighing.............	62	6	0
Passengers.....................	1	10	0
	63	16	0
Engine.........................	10	0	0
	73	16	0

with an average pressure of 150 lbs to the square inch, the "Pony" took them up 1 in 85 for a ¼ of a mile at 5 miles an hour, until she was purposely stopped.

The "Little Wonder" left Portmadoc the same afternoon with 72 loaded wagons weighing

	tons.	cwt.	qrs.
Slate trucks..................	138	17	2
Empty wagons..................	43	13	0
Passengers....................	4	0	0
	186	10	2
Engine........................	19	10	0
	206	0	2

Started with 165 lbs. of steam pressure and ran to the engine-house, and up the above gradient of 1 in 85, and was purposely stopped with steam at 125 lbs., and a low fire. Through the misapprehension of the engine driver, she was then backed down to the locality from which the "Pony" had started with 26 wagons, and the fire having been made up and steam raised to 170 lbs., she started freely, occasionally slipping, attained to a speed of 5 miles an hour with the 72 wagons, and after running about ¼ of a mile she was increasing speed on a gradient of 1 in 100, when she was purposely stopped with steam pressure of 170 lbs. to the inch.

In the above experiments the shorter trains were standing when they were started or attempted to start, partly on a curve of 4½ chains, and in the last experiment with the "Little Wonder," the train having been longer, it stood partly on a curve of 4½ chains radius, and partly on a reverse curve 8 chains radius. The length of this train was 648 ft.

The weather was fine, with a strong cold wind blowing against the trains, and the rails were in a remarkably good state for adhesion.

The slate wagons had no springs; the diameter of their wheels was 1 ft. 6 in., and that of the journals was 1¼ in.

The above report was signed by the Duke of Sutherland, Count Alexis Bobrinskoy, President of the Russian Commission; Lieutenant-General Sir Wm. Baker, R. E., K. C. B.; W. T. Thornton, Corresponding Secretary of Public Works Department, India; Juland Danvers, Official Director of Indian Railways; and Captain H. W. Tyler, Board of Trade.

SECOND SERIES OF EXPERIMENTS WITH THE FAIRLIE ENGINE ON THE 1 FT. 11½ IN. GAUGE.

The Result of an Experiment on the Festiniog Railway, on the 16th of February, 1870, with the "Little Wonder" (Fairlie Engine).

DESCRIPTION OF LOAD.

	tons.	cwt.	qrs.
22 wagons of coal...............	64	18	0
21 wagons of slates.............	49	3	1
2 bogie timber trucks [carrying timber in length 42 ft.].......	4	18	2
Passengers' weight..............	1	1	2
2 empty trucks between timber bogies.......................	1	4	1
1 workmen's carriage............	0	12	0
Engine..........................	19	10	0
Total...........................	141	7	2

Length of train with engine...........407 ft.

The whole distance to be run over from Portmadoc to Dinas, 13¼ miles, having a total rise from sea level of 703 ft., with maximum gradient of 1 in 74, and average gradient of 1 in 92 for 12¼ miles, the Traethmaur Embankment and Portmadoc of 1 mile in length being practically level. The maximum curves, 1¾ chains.

Average curves being 6.7 and 8 chains. The whole of the line being composed of a succession of curves with the exception of the before-named embankment, and three or four other short portions.

The train started from Portmadoc at 5.41 P. M. At Penrhyn Station, 5.58 P. M., without stopping there.

Arrived at Hafod Llyn Station at 6.18 P. M., where it stopped 8½ minutes.

Started at 6.26½ P. M., arrived at Ddu-allt Station (watering place) at 6.40 P. M., stopped 15 minutes on account of water being frozen, the tank could not be filled in the usual time.

The train reached the long tunnel at 7.2

P. M., through which it passed in 2 min. 10 sec. (length of tunnel 730 yards). Ran up to Tanygrissian Station, at which it arrived at 7.9 P. M., passed it slowly without stopping, arriving at Dinas at 7.15 P. M., having made the entire journey in 1 hour, 34 min., including stoppages, or exclusive of stoppages, 1 hour 10½ min.

Maximum speed...........15 miles an hour.
Average speed.............11¼ " "

The engine during the journey from Portmadoc to Hafod Llyn without slipping.

On starting from Hafod Llyn Station, a slight slipping occurred (the train being on a curve of 4 chains, with an inclination of 1 in 110), the rails being wet and greasy.

Slight slipping on starting from the watering place at Dduallt.

The engine slipped three times in passing through the tunnel, the rails being wet throughout.

Considerable slipping took place at the junction of branch line, this place being always wet and greasy, owing to the slate trains waiting for the down passenger train.

The pressure of steam ranged from 160 to 180 lbs., at which latter pressure the train started, the pressure being on one occasion only 145 lbs., for a quarter of a mile average pressure 175 lbs.

The entire journey was run throughout by the engine in "two-thirds gear."

There was a head wind during the whole of the journey, such being very strong in some parts of the line against the train.

Signed by Livingston Thompson, C. E. Spooner, Count Alexis Bobrinskoy, T. Rocheberg, Professor Saloft, R. Vandesen, J. Sementschinoff.

Third Series of Experiments with the Fairlie Engine on the 1 ft. 11½ in. gauge, under the Superintendence of the President and Engineer of the La Vendée Railway of France.

Started with a train of 140 empty slate wagons and 7 loaded coal wagons; gross load, 100 tons 16 cwt. 2 qrs.; length of train, 1,323 ft.; maximum speed, 16½ miles; average 12½ miles.

And on the return journey, the speed attained was 30 miles an hour over many portions of the road, the minimum being 25 miles.

THE FAIRLIE ENGINE ON THE 4 FT. 8½ IN. GAUGE.

Experiments on the 14th and 15th February, 1870, with the "Progress" Locomotive Engine.

The "Progress" is a double bogie engine with a four-wheeled bogie under each end. The cylinders are 15 in. diameter, by a stroke of 22 in. The wheels are 4 ft. 6 in. diameter, and are coupled together in both bogie frames, so that all the wheels of the engine are driving. The wheel base is 22 ft. The grate area is 19½ ft. The heating surface is, in the firebox, 92 ft., and in the tubes, 1,901 ft., making a total of 1,993 ft. The diameter of the boiler is 4 ft. 2 in., and the tubes are 388 in number, and 2 in. in diameter, outside measurement. The total length of the boiler is 24 ft. from tube plate to tube plate of the two smoke boxes respectively. The length of the tubes is 9 ft. 10 in. The total weight in working order, when the engine is fully equipped, is 54 tons, including 1 ton 15 cwt. of coal and 2,000 gallons of water. The engine is fitted with the steam brake of M. LeChatelier, and with an ordinary brake applied to all the wheels. The extreme length from buffer to buffer is 32 ft.

On the 14th February the "Progress" left the Three Cocks Junction of the Mid-Wales Railway with 39 loaded wagons and 3 brake vans, and about 50 passengers and workmen, making a total weight, exclusive of engine, of 472 tons 6 cwt. 2 qrs. It measured 710 ft. in length, besides the engine. It started from the Three Cocks at 3.6 P. M. with 130 lbs. of steam, as indicated by a Bourdons gauge. She proceeded freely from a gradient of 1 in 2,215. She passed two rising gradients of 1 in 75, the latter 29 chains long, and with the above pressure, but she slipped twice on a third gradient of 1 in 75, 34 chains long, and on reverse curves. After passing that gradient without difficulty, and a gradient 1 in 162, she came to a stand within 50 yards of the summit of a gradient of 1 in 90, 21 chains long. The steam pressure was then 120 lbs. to the square inch. The water having fallen to near the bottom of the gauge glass, Mr. Fairlie, who was driving the engine, and was unacquainted with the gradients, applied both injectors

about 30 chains from the point where the engine pulled up at 3.35 P. M. The total distance run was 6½ miles in 29 minutes.

There was a strong wind blowing across the train, with hoar frost, and the rails were in excellent condition. The axle-boxes of the wagons had been greased in the ordinary way. The engine was unable to start the train after it stopped, though the pressure had been increased to 150 lbs.

On the 15th of February the "Progress" left the Three Cocks at 10 hours 47 min. 30 sec., with 140 lbs. of pressure, and with a load of 40 wagons, and 2 vans, and about thirty passengers. The train was 720 ft. exclusive of the engine, and weighed altogether 475 tons 16 cwt. 2 qrs.

She proceeded freely to the water tank, 3 miles from the Three Cocks, and stopped there at 11 hours 0 min. 30 sec., with 115 lbs. of pressure. But the tank having been partly frozen, no additional water could be obtained by the trough. She started again at 11 hours 6 min. and 30 sec., with 125 lbs. pressure, and went straight forward to Builth, passing Erwood, 7 miles from the Three Cocks, at 11.27 P. M. She reached Builth, 14 miles from the Three Cocks, at 11 hours 50 min. 30 sec., with 100 lbs. of pressure, it being level for the last mile to Builth the engine fire was lowered and the boiler pumped full of water. She did not stop between Three Cocks and Builth. She passed the point at which she had stopped on the previous day, at 8 miles an hour, and with a pressure of 140 lbs. to the inch. The engine on this day was driven by Edward Williams, under the supervision of Mr. Greenhow, the locomotive superintendent of the Mid-Wales Railway.

On the 15th February the "Progress" left Tall-y-llyn at 2 hours 51 min. 30 sec., with 13 loaded wagons and 2 brake-vans, and with a steam pressure of 125 lbs. After running for three miles for the most part a descending gradient of 1 in 40, she was brought to a stand at Taly-bont Station, where her tanks were filled. She started from Taly-bont at 3 hours 13 min. with a pressure of 140 lbs., and ascending a gradient of 1 in 35 for half a mile. She then mounted a gradient of 1 in 38 for 6⅝ miles, and passed the summit of that gradient at 4 hours 16 min. 15 sec., with 120 lbs. of pressure, she passed through the tunnel 660 yards long as a rising gradient of 1 in 68 in 2 min. 15 sec., and was stopped at the Torpantau Station at 4 hours 18 min. 30 sec., the pressure continuing the same. This portion of the line contained curves of 12.16 and 20 chains radius, as the rising gradient of 1 in 38, the train having sometimes been passing over reverse curves.

The water gauge burst at 4½ miles from Taly-bont, and the engine driver, Edward Roberts (who was acting under the superintendence of William Barker), was without any means of ascertaining the state of the water in the boiler, inasmuch as there were no steam cocks on the boiler. The engine did not slip at all on the 15th. The weather was fine and dry as on the 14th, but with more sunshine and rather less wind.

MATERIALS FOR CONSTRUCTION IN EUROPE.

We abstract from Commissioner Blake's Report,* the following statements regarding the materials used in engineering structures in middle and western Europe:

Among the hard stones worked in France are the syenites, granites, and porphyries of the Vosges, the green melaphyre of Tournay, the granites and protogines of Mont Blanc. The jaspers of St. Gervais, near Mont Blanc, are attracting much attention for their beauty and novelty. The quantity is supposed to be inexhaustible, and blocks of large size are obtained. The rock is believed to result from the metamorphism of a bed of sandstone of the Triassic period.

It is banded and brecciform in structure, and presents a great variety of colors most capriciouly mingled, the most conspicuous being blood red, rose, and green. It is traversed by veins of white

* "Civil Engineering and Public Works," by William P. Blake, Commissioner of the State of California.

quartz. These beautiful jaspers were represented at the Exposition by two splendid columns at the entrance of the glass-house for the equatorial plants. Similar columns have been placed in the new Opera House. The cost of the stone is 1,500 francs the cubic metre at the quarry, and 200 francs delivered in Paris, but it is supposed that when the quarry is fully opened the price will be reduced.

Of marbles France has a bountiful supply. They are obtained chiefly in the Vosges, the Alps, and Pyrenees, and from Boulogne and the Jura. Quarries at the last-named locality are regularly worked on a large scale, and blocks are furnished at low prices.

The French section contained a great many beautiful marble columns designed for the new Opera House. The marbles came from the quarries of Sarrancolin (Hautes-Pyrenees), St. Beat (Haute-Garonne), Félines (Hérault), St. Antonin (Bouches-du Rhone), Porcieux (Var), Jeumont (Nord).

According to the French customs returns, the exportation of French marble, which was valued at only 350,405 francs in 1855, constantly increased until the value had reached 1,140,279 francs in 1866. The importation of marble has also increased regularly during the same time, being valued at 1,038,271 francs in 1855, and at 2,357,115 francs in 1866. The disposition to use marble in construction is increasing in France.

The following figures show the prices in francs per cubic metre of the marble most in use in France during 1867. These figures and the preceding relating to the marble industry of France are compiled from the Report of Prof. Delesse:

Sarrancolin	1,012
Campan mélange and Campan vert	1,232
Rosé clair	792
Griotte d'Italie	1,012
Griotte œil de perdrix	1,117
Languedoc	792
Brèche Imperiale	682
Vert de Maurin (serpentine)	1,122
Brocatelle jaune, violette ou jaune fleurie	847
Sarrancolin de l'ouest	572
Henriette	627
Noir française	374

The display of marbles from Italy was peculiarly fine, remarkable alike for the beauty of the material and for the liberality and taste displayed in the selection of the specimens. They were in blocks a foot square and beautifully polished. The institute Technico de Firenze also sent a splendid series of specimens of all varieties of the Italian building stones, among them a series of sixty polished blocks of serpentine of as many different shades and colors.

From Algeria there was a fine collection of some 400 specimens, in cubes measuring 6 inches on a side, of the building stones of that country. These were collected by the "Service du genie militaire, des ponts et chaussées." The series contained a great variety of marbles, among them the beautiful light-colored "onyx marble," so-called, now much prized and used for interior decoration in France.

Belgium is extremely rich in marble of various colors, particularly the much esteemed black marbles. They are obtained in the provinces of Namur, Liege, and of Hainaut. Of the black marbles, those of Denée and of Furnaux are much exported to France, Germany, and Italy. The fine black marble of Golzinnes is nearly all sent to Paris. The black marble from the quarries of Peruwelz and of Basècles (Hainaut) is very solid, and is exported in considerable quantities to all parts of Europe and to America.

There are 90 marble quarries in the province of Namur; they employ nearly 806 men, and the value of the annual production is estimated at 860,000 francs. The quarries of Wellin yield nearly 400 cubic metres of marble annually, of a value of 40,000 francs. It is estimated that not less than 3,000,000 francs of capital is invested in the marble industry of the province of Namur alone.

But Belgium is rich in quarries of all kinds of building stone; not only marbles, but granite, paving stones, sandstone and slates.

The marbles of Algeria were well represented at the Exposition, particularly the "marble onyx" from quarries worked formerly by the Romans. It is beautifully veined in parallel layers like onyx, and appears to be of stalagmitic origin. It resembles the Mexican stalagmitic marble. Fine specimens of onyx marble were shown also in the Russian section.

From Scotland and from Cornwall there were several very finely wrought specimens of granite, and from Sweden a fine display of the porphyry of Elfdalen. In the Bavarian section there were two fine vases of a green dioritic porphyry.

The following table shows the weight in kilogrammes, per cubic metre, of some of the various stones employed in the construction of the new Grand Opera House of Paris, and the pressure per square centimetre which each will sustain before crushing.

Weight and strength of some of the varieties of stones used in the construction of the Grand Opera House.

Description of Stone and Locality.	Weight.	Crushing Weight.
Jasper of Mount Blanc, St. Gervais	2,716	1,839
Brown granitoid porphyry Bazoches	2,585	1,487
Green porphyry (melaphyre)	2,855	1,111
Red granitoid porphyry, Autun	2,585	1,080
Porphyroidal granite, St. Martin du Puy	2,567	1,077
Micaceous granite, Lormes	2,694	1,077
Red syenite, Servance	2,651	901
Syenite ("feuille-morte"), Servance	2,683	867
Porphyroidal granite, Servance	2,643	715
Marble ("sanguin") Sampans, Jusa	2,637	1,076
Marble (violacé)	2,663	994
Pierre de Damparis, Jura	2,683	898
Pierre de l'Echaillon, Commune de Rivière	2,726	852
White Echaillon, St. Quentin	2,529	781
Yellow Echaillon, Lignet	2,686	777
Rose-colored Echaillon	2,472	606
Pierre de Anstrude, Yonne	2,261	365
Soft stone, Yonne	2,161	369
Pierre de Ravières	2,157	377
Grès bizarré, Lutzelbourg	2,130	215

CEMENTS AND ARTIFICIAL STONES.

Cements were exhibited in great variety from France and Belgium, not only in the crude and commercial state, but worked up into various objects and moulded into blocks of a form suited for testing by pressure and weighting.

One of the most interesting displays was made by the French Cement Company of Boulogne-sur-Mer, which received a gold medal. An apparatus for testing the strength of cements was included in their exhibition. Blocks of the hardened cement, about 8 inches long and shaped like a stout letter I, were placed between strong iron clamps, and made to form a link in the chain by which a heavy platform was suspended. Upon this platform below, heavy weights were piled nearly to the limit of the strength of the slender neck of the cement block. One of these blocks, formed of 4 volumes of sand and 1 of cement, and 1½ in. square, sustained a strain of 900 kilogrammes. Another one, four inches square, composed of 2 volumes of sand and 1 volume of cement, sustained a weight of 1,200 kilogrammes. The sand used in these experimental blocks was very coarse, nearly as large as beans or peas. Another method of showing the strength of their cement was by building a column of brickwork about six feet long, extending horizontally like an arm, and supported at one end only.

This cement is artificially prepared by mixing intimately and with great care 79½ per cent. of carbonate of lime, in powder, with 20½ of clay, and then burning at a high temperature. There are now many establishments in France, Prussia, Germany, Austria, and Russia, where enormous quantities of excellent cement are manufactured. In one of the establishments recently started in France, at Pouilly, the method consists in crushing together two kinds of argillaceous limestone from the Lias; one containing 43.5 per cent. of lime, the other a belemnitic limestone, which contains 48 per cent. of lime. The first gives the cement known as the Pouilly, and the intimate mixture of the two gives a cement with the composition of the Portland cement. An analysis of this cement gives the following result:

Lime	62.00
Silica	23.00
Alumina	8.50
Oxide of Iron	5.50
Water and carbonic acid	1.00
Sulphate of lime	traces.

M. Delesse gives the results of some recent analyses of Portland cement by Dr. Zuirek, of Berlin, as follows: three samples came from the principal works for the manufacture in England, and the fourth from the establishment of the Brothers Menkow at Schwerin:

Analyses of four samples of Portland cement.

	Robins.		White Bros.		Knight, Bevans & Sturge.		Menkow.	
Silica	22.74	92.08	22.59	92.56	22.30	95.02	24.01	97.68
Alumina	7.74		6.43		3.31		5.73	
Oxide of iron	3.70		4.03		9.75		2.39	
Lime	56.68		57 87		58.17		63.77	
Magnesia	0 57		0.55		0.91		0.96	
Potash	0.46		0.74		0.41		0.49	
Soda	0.19		0.35		0.17		0.33	
Sulphate of lime	1.66	7.59	2.67	6.51	1.17	5.02	0.24	2.11
Carbonate of lime	3.50		0.84		1.34		0.67	
Insoluble residue	0.50		0.77		1.06		0.93	
Hygrometric moisture	1.90		2.23		1.47		0.27	

The Vicat cement is much more used in France now than formerly. It is manufactured on a large scale by Mr. Joseph Vicat, a graduate of the Ecole Polytechnique, and the son of the celebrated engineer. He forms a paste with clay and slaked lime in powder. This is made into loaves, which soon set and harden so that they are not injured by the weather, and do not require housing or artificial drying, as is the case when unburned materials are used. These loaves are then burned. This is substantially the process invented by his father. M. Delesse observes of the qualities of this cement, that it is homogeneous, the elements being in perfect combination ; the clay is changed into silicate, which is completely decomposed without residue in a dilute acid. The setting is slow and does not commence for several hours after the mixing as mortar. The weight of this cement pulverized, but not compacted by ramming, varies from 1,300 to 1,400 kilogrammes to the cubic metre.

Some interesting applications of this cement were shown. It is used for making artificial breccias by mixing it with fragments of marble of various colors, moulding it into the desired form, and then by grinding and polishing the surface a beautiful mosaic is produced. Blocks so made may be sawed into slabs and polished like marble. They are hard and non-absorbent of moisture, and are said to be suitable for exterior decoration.

Among the hydraulic limes, that of Theil, Ardèche, continues to hold its high rank. The limestone beds from which it is obtained are highly fossiliferous, and are over 300 feet thick. Simple burning is all that is required to produce the cement. An establishment for its manufacture at Lafarge has 34 furnaces and produces 340 tons of sifted lime daily. The price is 15 francs per ton, and it weighs 700 kilogrammes per cubic metre. It is particularly valuable for marine constructions, and can be wetted with either fresh or salt water. It was used for the formation of the artificial blocks sunk to form the breakwater piers at Port Said.

The agglomerated béton of M. Coignet was most fully represented at the Exposition, and was used in the construction of the reservoirs and for the foundations of the outer gallery. For a full description of this material, its preparation and uses, reference is made to the special report by Mr. Leonard F. Beckwith. Reference may also be made to the publication by M. Coignet,* and by M. Claudel.†

OXYCHLORIDE OF MAGNESIUM CEMENT.

By mixing magnesia with oxychloride of magnesium a cement is formed analogous to that made with zinc oxide and the oxychloride of zinc. Both of these cements are the invention of Mr. Sorel. The hardness of the cement varies with the density of the chloride solution. An increased hardness is given by saturating the chloride of magnesium with chloride of barium or with sulphate of magnesia. The addition of 1 part of quicklime, or 2 parts of carbonate of magnesia, in 100 of the chloride at 25 deg. Baume, augments the hydraulic properties.

* Emploi des bétons agglomérés, etc., par François Coignet. Paris, 1862.

† Pratique de l'art de construire. Paris, 1868.

FERRUGINOUS CEMENT.

M. Alfred Chenot proposes to form a ferruginous cement by mixing iron in a state of extreme subdivision with sand. A cement so formed has long been known and used to a certain extent in the United States. M. Chenot proposes to manufacture the iron in a state of sponge and upon a large scale, by reducing iron ore, mixed with carbon, in a close furnace.

RANSOME ARTIFICIAL STONE.

This remarkable compound is adapted not only to interior, but to exterior construction, and rivals the natural sandstones in hardness and durability.

It is formed by mixing sand with soluble silicate of soda, and, when moulded into the desired form, treating the mass with a solution of chloride of calcium. A double decomposition takes place, hydro-silicate of lime is formed, and binds the grains of sand strongly together. For a full description of this artificial stone and its applications, reference is made to the report by Commissioner Barnard upon the Industrial Arts.

ZINC FOR CONSTRUCTION.

Zinc in its various forms of sheets, wire, nails, and stamped ornaments, appears to be much more used in construction in Europe than in the United States. The display by the Vieille-Montagne Company, and the Silesian Zinc Company of Breslau, was very extensive. Some of the advantages claimed for this material over other materials for roofing are its lightness, tenacity, and cheapness compared with lead, slates, or tiles. The Vieille-Montagne Company claim that the inclination of zinc roofs need not exceed 0m.1 per metre, while slate requires 0m.3, and tile 0m.45.

For a building 12m.50 long by 6m.80, covered with No. 14 zinc, at 80 francs the 100 kilogrammes, the cost would be:

	Francs.
With zinc, 1,075.09 francs, or per square metre	13.45
With slates, 1,245.97 francs, or per square metre	15.60
With tiles, 1,745.96 francs, or per square metre	21.80

For a shed 63m.00 long, 18m.00 wide, with an iron frame, and covered with No. 14 corrugated zinc, at 80 francs per 100 kilogrammes, the cost would be:

	Francs.
With zinc, 18,749 francs, or per square metre	16.50
With tiles, 22,767 francs, or per square metre	20.10

For temporary constructions they advertise sheets Nos, 10 and 11, which weigh 3k.45 to 4k.15 per square metre. It does not require painting, and the old sheets may be sold for 35 to 40 per cent. of the cost of new.

The Silesian Zinc Company manufacture zinc sheets of all sizes and thicknesses, from 2 ounces per square foot upward. The large plate exhibited is 17 ft. long by 54 ins. wide, and three-quarters of an inch thick. It could have been made twice as long as this, and with a total weight of 4,200 lbs., if room could have been procured for its installation. The corrugated sheets of large curve when laid lengthwise are made 9 ft. long and up to 40 ins. in breadth. These sheets are used chiefly for roofing large railway stations and other large buildings. The new Exchange at Berlin is covered with zinc from this establishment.

Some papers on the action of compressed air have recently come before the French Academy; and on the occasion of M. Delaunay remarking on bolides and aerolites, General Morin observed that artillerists found that in firing over a level near the ground, the dust was raised right and left by the compressed air acted upon by the ball. Ancient cannoneers, he said, spoke of valleys as attracting balls, because in such situations the compressed air afforded the greatest obstacle to their passage. In firing along a horizontal wall, and near it, balls deviated, so that if the wall was at the right, the balls went to the left, and *vice versa*.

We learn from "Cosmos" that in 1866 the 1,043 gold mines belonging to Russia, produced through the labors of 60,000 workmen, 26,560 kilos. of pure metal. Siberia alone possesses 500 auriferous sources, employing 34,000 persons. The Russian production of silver is less, for the various mines only produced 18,000 kilos. From the 7 platinum mines 1,712 kilos. were extracted. The Oural mountains and other places yielded 4,320 tons of excellent copper.

THE FESTINIOG RAILWAY.

Abstract from "The Engineer."

More than four years ago Captain Tyler, R. E., gave to the Institution of Civil Engineers a very complete and exceedingly interesting account of the little 2 ft. gauge, single line railway, extending from Portmadoc to Festiniog and Dinas, in Merionethshire. Precise and circumstantial as was this account, however, none who have not seen the line itself can possibly form an adequate notion of its extraordinary features. It may seem easy enough to imagine a 2 ft. gauge, or even easier to *see* it by laying down a couple of railway or other bars, or even a couple of light timber scantlings 2 ft. apart. But these bars or scantlings will not even then look like a practicable railway, and still less so if they have not their corresponding concomitants of liliputian earthworks —liliputian in respect of width, although not necessarily so in respect of depth or height. Look at them how you may, and in the light of a strong imagination, and they will appear but a pair of bars temporarily divorced from a common heap. You may compare them, if you have visited the cellars of the great London or Burton breweries, to the narrow lines of way along which casks of beer are rolled into dark distance, and into a highly carbono-acidulous and alcoholic atmosphere therein. You may compare them to the twin sides of an iron ladder, "barring" the rounds. Yet the 2 ft. railway gauge, or rather the 2 ft. 1 in. gauge, may be seen even in London, and for miles to the west, out of London. Within the 7 ft. gauge of the Great Western, a third rail has been laid down for the 4 ft. 8½ in. gauge, and, between Didcot and Wolverhampton, the inner rails of the 7 ft. gauge have been removed, leaving the old "six foot," as the intermediate space is termed, about 11 ft. wide, between the two 4 ft. 8½ in. gauges; the up and down lines, from their distance apart, appearing to belong rather to competing companies than to the same company, and seeming, indeed, to be in adjoining counties, or, at any rate, in separate "districts." But between Paddington and Didcot the inner rails of the 7 ft. gauge still remain, and between them and the inner rails of the 4 ft. 8½ in. gauge is a clear width of 2 ft. 1 in. If the traveller can imagine a real railway, of 1 in. less width, he may form some notion of the Festiniog line; not, however, as an entire railway, but in respect of its gauge alone. And would you, the passenger, consent to be whisked down to Didcot, at from 30 to 40 miles an hour, over that remanet from the 7 ft. gauge—that remanet of 2 in.—we mean 2 ft 1 in.—gauge? Look for a little time down that interminable perspective, and the 2 ft. 1 in. gauge converges to 18 in., to 12 in. to 6 in., to nothing at all. Even the 2 ft. gauge at your very feet seems, as you look again and again at it, to contract to 20 in., or even to 16 in. You cannot quite believe it to be even 2 ft., until you have measured it once more, and then you wonder why it was not laid down to a one-foot gauge, which, you almost believe, might have answered just as well. Indeed, you verge upon the late Mr. Holworthy Palmer's theory of no gauge at all—a single rail, from which, in his short railway near Posen, in Prussia, he suspended his carriages, but upon which, laid on the ground, you would suppose steam bicycles might be run, especially after Professor Rankine's more than wonderful recent algebraic analysis of how bicycles run at all. It may be—we cannot prophesy—that the velocipedestrian mania may result at last in working heavy trains over a single rail, and the Festiniog is certainly the nearest practicable approach yet made to this mode of working.

But it is not alone the narrowness of the gauge. There are curves as sharp as the sweep of Oxford Circus—at any rate of but 116 ft. radius for short lengths, while others are of 150 ft. to 264 ft. radius only. It is true they are parabolic curves, eased off from the straight line, and only gradually attaining and as gradually verging from their minimum radius. But over the extra-narrow gauge, and through these curves, almost sharp enough to be called corners, steam-drawn passenger trains are worked at a nominal regulation speed of 12 miles an hour, but at an actual speed sometimes exceeding 30 miles an hour, while the engineer of the line expresses himself equally ready, if the Board of Trade will sanction it, to run 40

miles an hour! And it is the fact that this line, having a total length of 14¼ miles, including branches, has been worked by locomotives for more than six years without a single accident other than what might have equally happened upon any gauge, viz., engines or wagons running off at points which had been set wrong. The successful working of the line is *un fait accompli*—a fact of 6 years' duration. So narrow and so crooked a line has no business to be worked at all; you seem to think it cannot be—never was—worked, but there is the fact. It *does* work, and, what is more, it pays. The traffic receipts of the little Festiniog line, from £30 to £40 per mile per week, exceed those of the North Staffordshire or of the Cornwall Railway, while they are very considerably above those of the Cambrian system of railways, and are greatly more than those of most of the Irish lines. And the whole cost, including a mile of breakwater in the Glaslyn estuary, half a mile of tunnelling, and an almost uninterrupted series of cutting in syenite rock, and breastwall embankments, or, rather rubble stone viaducts, together with stations, workshops, 7 locomotives, and more than 1,000 wagons and carriages, has been about £6,000 per mile. It is the pecuniary success of the Festiniog line, which pays about 30 per cent. upon its original capital of £36,000, which makes it doubly interesting. Upwards of £50,000 have been expended upon improvements, and this, taken from revenue, has since been capitalized, making a total capital amount of, say, £86,000, upon which about 12½ per cent. is now paid.

But it is not alone the gauge, nor the curves, nor the safe and profitable working of the line which make it interesting to the engineer. Nor is it even the grand scenery which it commands in the Maentwrog Vale. Festiniog is 700 ft. above Portmadoc, the elevation being accomplished in less than 12 miles, giving an average gradient of 1 in 92, and a maximum gradient of 1 in 80. The line is cut into and embanked upon the steep right hand slope of this valley, furrowed as in this slope with the deep hollows of the mountain watercourses; and the cuttings, tunnels, and embankments are equally striking with the permanent way itself. The width between the nearly vertical sides of the cuttings is but about 8 ft., allowing hardly room for driving a cab through them; the two tunnels—one of 60 yards, and the other 730 yards—are scarcely larger in cross sectional area than the trains themselves; while the embankments, if we may give them that name—the engineer calls them "breastwalls"—are almost invariably stone walls 8 ft. wide at the top, with a batter of 1 in 6 on each side. Some of these breastwalls are 50 ft. or more in height, and are sharply curved. There are no parapets, and the passenger carriages almost overhang their edges, presenting a fine opening for destruction. An engineer from any railway of ordinary gauge, especially a double line, would look upon the work of the Festiniog Railway as but little more than a bridle path, resembling some of the narrow ways in the Alpine passes, or in the world-famed pathway from Laguayra to Caraccas in Venezuela. Indeed, the national duocorn of Wales, the Cambrian goat himself, would hardly find more than comfortable footing along the Festiniog line. Sheep stray upon the line, and we should ourselves have made Welsh mutton of a small flock of them, last Saturday, had they not considerately jumped in time down a steepish embankment.

As the two-feet gauge seems to grow narrower and narrower, the more you look at it, the most wonderful thing of all is that it should be worked by locomotives at all. Yet there are fine, although small engines, seven in all, designed and built by Mr. George England and Mr. R. F. Fairlie, who, alone, were prepared to carry out Mr. C. E. Spooner's (the engineer's and secretary's) requisition to work the line by steam power. We will not now repeat the names of some of the very first engineers of ten years ago, who, in Parliamentary committees, maintained that no useful, if indeed a safe, application of locomotive power could possibly be made on so narrow a gauge. It is enough to say that no locomotive builder, other than Mr. George England, could be found to guarantee any useful performance of locomotives upon such a line, and that, worked at from 160 lbs. to 200 lbs. steam, his engines have done very much more than he guaranteed they should do. These engines are, in themselves, great curiosities. The largest driving wheels among them are but 2 ft. 4 in. in diameter, while the prevailing size is 2 ft. These wheels

are worked, for the most part, by 8 in. cylinders, the pistons having 12 in. stroke, and with 160 lbs. to 200 lbs. steam in the little boilers, they can pull from 40 to 70 empty slate trucks, weighing 13 cwt. each, together with goods trucks and passenger carriages, up the 700 ft. rise in 12 miles, at the rate of as many miles an hour.

The Festiniog line affords an admirable proof of the advantage to be gained by resorting to a small gauge when the conditions of traffic permit; no one in his senses would, we fancy, abandon the wide gauge for the narrow under any other circumstances. Mr. Ramsbottom has laid down a line still narrower at Crewe. This little railway thoroughly answers the purpose for which it was intended. It is adapted to the demands made upon it, and it is therefore successful. In Norway Mr. Pihl has constructed two railways—one from Throndhjein to Storen, and the other between Hamar and Eleverum. The gauge is 3 ft. 6 in. The total cost of the Hamar line—24½ English miles long—was about £3,000 a mile. This includes an iron bridge 900 ft. long, 3 locomotives, 6 passenger carriages, 3 break-vans, and 50 goods wagons, with ballast wagons, and repairing shops and tools, 2 terminal stations, and 6 intermediate stations. The line rises 400 ft., and crosses many extensive and deep swamps. The Throndhjein line—31½ miles—cost £5,000 per line, including 4 engines, 8 passenger carriages, 3 break-vans, 60 goods wagons, and 20 ballast wagons, 2 terminal, and 6 intermediate stations, goods and carriage shades, and a repairing shop. For the following description of the line we are indebted to a statement made by Mr. Bruff, assistant engineer to Mr. Pihl, at the Institution of Civil Engineers in 1865:

"This line had to cross a ridge more than 500 ft. in height, in the first Norwegian mile from Throndhjein. The greater part of this distance was constructed on one side of the ridge, with gradients of 1 in 42 and 1 in 65, and on the other side of 1 in 52, the curvature being of about 900 ft. radius; whereas on the other portion of the line, where the gradients were seldom more than 1 in 100, curves of 750 ft. were frequently resorted to. The width at the formation level in cuttings and on embankments was 13 ft. nearly; the slopes, according to circumstances, were from 1½ to 1 to 3 to 1. The ballast was 8 ft. wide at the top, and 1 ft. 9 in. in thickness; the sleepers were of half round pine, 6 ft. 6 in. long, placed 2 ft. 6 in. apart on the curves and steep gradients and 2 ft. 9 in. on the straighter portions of the line. The rails were flat-bottomed and fished at the joints in the usual way, 3¼ in. in height, and weighing 37 lbs. per yard, except on the steep inclines, where rails of 41 lbs. per yard were laid. The rails were fastened to the sleepers by dog-spikes only, no bolts or bottom plates being used. Ransome's chilled crossings and Wild's self-acting switches were used throughout. The bridges were all of timber, except where large rivers had to be crossed, and spans of from 50 ft. to 100 ft. were required, in which case stone piers were carried up above flood level. The superstructure made use of in those cases was Howe's system of trellis work, w th iron suspending rods. For the other bridges and viaducts a simpler plan was generally adopted, and though of light and cheap construction, it had proved very satisfactory with regard to stiffness and solidity, even at heights of more than 90 ft. The rolling stock consisted of tank engines with 3 pairs of wheels, 2 pairs being coupled for drivers, these having an available weight for traction of from 11 to 12 tons, out of the 14 to 15 tons, the total weight. The last engines procured were provided with bogies, on Bissel's or Adams' system. The cylinders were 10 in. in diameter, with a length of stroke of 18 in., and the driving wheels were 3 ft. in diameter. All the engines were made in England, with the exception of 1 made at Throndhjein, and were working efficiently. The passenger carriages were constructed to carry the usual number of carriages as in England, and were arranged for 2 classes only, the compartments being fitted up as first and third. The goods wagons were made to carry 5 tons, and were only a few inches narrower than the ordinary kind, these widths being obtained by having the springs attached to brackets inside the sole bars, thereby allowing the lowering of the body, and, in consequence, the centre of gravity. The buffers were all central, and 2 ft. 6 in. above the rail level, and served also as draw-bars. The couplings on those last constructed were self-acting when the wagons were brought together. As this narrow gauge allowed a correspondingly larger

wheel base than the ordinary gauge, the wagons ran very steadily. Some of the wagons were constructed to carry planks 24½ ft. long, and had a length of wheel base of 13 ft. The usual rate of speed was about 15 miles per hour, including stoppages, and the trains ran quite as steadily on this line as on the broader gauges. The traffic on these lines, though considerably below that of the lowest of the English lines, had already fully paid the working expenses, while the impulse given to the development of the resources of the country must undoubtedly, in course of time, produce a corresponding and satisfactory increase of revenue.

Simultaneously with the construction of the two narrow gauge lines, an extension—50 miles long—of the original trunk line, laid to 4 ft. 8½ in., was made to the Swedish frontier, the cost of which £6,400 per mile, the rate of wages and the class of work being as nearly as possible the same on all 3 lines. From this it appears that the broad gauge cost £1,400 per mile more than one, and £3,700 per mile more than the other narrow gauge line.

We have recently been placed in possession of some additional facts regarding the Norwegian lines, which we publish for the benefit of our readers. The following experiment was carried out long since to determine the tractive resistance on the 3 ft. 6 in. gauge. A train was made up consisting of a locomotive of the Bissel bogie type—11 in. cylinders, 18 in. stroke, 4 coupled drivers 3 ft. 9 in. diameter, total weight on drivers, 12.85 tons, of engine, 17 tons, and 16 plank trucks 26½ ft. long each over all, 13 ft. wheel base; weight of each with load, 8¼ tons. This train was taken up a gradient 2½ miles long, of 1 in 118 in part, and 1 in 100 for the last mile at the top, with curves of 1,000 ft. and 980 ft. radius. The speed on the lower portion of the incline was 14 miles an hour; on the upper part, 10 miles an hour; boiler pressure, 100 lbs. to 120 lbs. The resistance per ton is about 11.75 lbs.

We have arranged in the following table particulars which explain themselves, and for which we are indebted to an English engineer, to whom they were supplied by Mr. Pihl:

List of prices, weight, carriage capacity, etc., of carriages and wagons on the 4 ft. 8½ in. gauge and the 3 ft. 6 in. gauge railways in Norway.

	Prices.	Length of body.	Width of Body.	Weight.		Carrying Capacity.		Weight of Carriage per one Passenger.
				Total.	Per foot run.	Total.	Per foot run.	
Composite first and second-class carriage, 4 ft. 8½ in	£328	20 ft.	7 ft. 3 in. to 8ft.	6.4 tons.	6.4 cwt.	32 pass.	1.6 cwt.	4.0 cwt.
Composite first and second-class carriage, 3 ft. 6 in..............................	230	20 ft.	6 ft. 10 in.	5.45 "	5.45 "	32 "	1.6 "	3.4 "
Second-class carriage, 4 ft. 8½ in........	240	20 ft.	7 ft. 3in. to 8 ft.	6.02 "	6.02 "	28 "	1.4 "	4.3 "
" " " 3 ft. 6 in..........	131	20 ft.	6 ft. 10 in.....	3.80 "	3 80 "	28 "	1.4 "	2.7 "
								Carrying capacity per ton weight of wagon.
Lowsided goods wagon, 4 ft. 8½ in.	90	16 ft.	7 ft. 4 in......	4.15 "	5.2 tons.	6 0 tons.	7.5 cwt.	1.45 cwt.
" " " 3 ft. 6 in.	64	16 ft.	6 ft. 6 in......	3 3 "	4.1 "	6.0 "	7.5 "	1.82 "
Plank and timber wagon, 4 ft. 8½ in....	90	18 ft.	7 ft. 6 in......	4.4 "	4.9 "	6.0 "	6.7 "	1.36 "
" " " 3 ft. 6 in......	62	18 ft.	6 ft. 6½ in....	3.0 "	3.3 "	6 0 "	6.7 "	2.00 "
" " " 3 ft. 6 in......	62	23ft. 6in.	6 ft. 8½ in....	3.25 "	2.77 "	6.0 "	5.11 "	1.85 "

N. B.—When measured from outside to outside of buffers, 3 ft. is to be added to the length for the 3 ft. 6 in. gauge stock, and 3½ ft. for passenger carriages, and 2 ft. for goods wagons on the 4 ft. 8½ in. gauge stock.

THE French Government has sanctioned M. Duc's gift of 40,000 francs to the Academie des Beaux-Arts, for the purpose of founding a prize for the encouragement of architectural studies.

THE building of the new Roman Catholic church, at Arundel, England, has commenced. The height to top of spire will be 250 ft., and the cost will be £50,000.

IRON AND STEEL NOTES.

IMPORTS OF FOREIGN IRON AND STEEL AT NEW YORK.—For the week ending March 11, 1870.

	Quantity.	Value.
Railroad Iron, bars	2,099	$14,807
Hoop, tons	98	4,087
Sheet, tons	88	4,310
Pig, tons	290	4,685
Other Iron, tons	1,424	40,351
Chains and Anchors, packages	121	3,729
Tubes, packages	1,850	4,377
Nails, packages	7	447
Steel, packages	1,409	16,235
Machinery	37	3,973
Pipes	—	5,164
Anvils	30	246
Wire	855	5,990
Total value		$108,401

IMPORTS OF FOREIGN IRON AND STEEL AT BOSTON.—For the week ending March 11, 1870.

	Entered for consumption—Value.	Warehoused—Value.
FROM ENGLAND.		
Pig Iron	$6,775	....
Manufactured Iron	18,855	6,179
Scrap Iron	....	....
Wire Rods	....	....
Wire Rope	....	....
Iron Rails	....	....
Machinery	8,878	....
Nails	....	....
Chains	609	....
Steel Rails	....	....
Steel Tires	....	....
Steel	11,835	276
Steel Wire	....	....
Files	....	....
Pipes	....	....
Manufactures of Iron	505	....
Manufactures of Steel	630	....
Anchors	....	....
Anvils	....	....
FROM CHINA.		
Manufactured Iron	582	....
FROM BRITISH WEST INDIES.		
Scrap Iron	....	70
FROM HAYTI.		
Scrap Iron	50	....
FROM SWEDEN AND NORWAY.		
Manufactured Iron	32,958	....
Pig Iron	225	....
Total	$81,902	6,525

—*Bulletin of Am. I. & S. Asso.*

STEEL IN THE UNITED STATES.—The "Protectionist," speaking of the progress making in the manufacture of steel in the United States, says:

"Within the last six years it has been demonstrated that the steel-producing qualities do exist in American iron, and many of our best edge-tool manufacturers and machinists testify that steel, both cast and rolled, made in Pittsburg from American iron, is fully equal to the best English makes.

"The steel-producing capacity of the works in and around Pittsburg alone, is estimated at 75 tons per day. This industry may, therefore, be deemed an accomplished fact, and brief as its history is, it has already exercised an important influence in controlling foreign prices."

It is shown that American axes, shovels, spades, hoes, etc., have entirely taken the place of foreign tools. Nothing equal to them in shape or finish is made abroad, and they are now largely exported. American butts and hinges of all kinds are cheaper and better, and entirely excludes all foreign goods. In cutlery of all kinds, the medium American qualities, of which the largest bulk enter into consumption, are cheaper and better than those of foreign importation; only the very low and worthless grades, or the very expensive and luxurious styles, can now be imported.

HOMOGENEOUS IRON RAILS.—Chief Engineer Stockton, of the Allegheny Valley Railroad, in his annual report, makes the following comparison between iron and steel rails:

"In regard to the durability of iron rails I have never seen a rail perfectly homogeneous worn out; neither have I ever heard any civil engineer say that he had, and I have frequently asked the question. In speaking of these things to a prominent iron manufacturer of this city, he kindly proposed to furnish to this company a couple of iron rails made from his common merchant bar. These were received and laid on the track in March, 1868, and on the opposite side of the track were laid steel head-rails, manufactured in Michigan. Both were laid at a point where it was supposed they would receive the roughest service. In less than six months some of the steel rails had given out, and shortly after they were lifted and Brady's Bend rails supplied. These were worn out and others supplied and worn out, while the two rails furnished by the party above referred to, remain in the track apparently little the worse for the service."

RAILROAD IRON.—A correspondent writes as follows to the Boston "Commercial Bulletin:"

We know that Great Britain now consumes and markets 5,000,000 tons of iron annually, whereas for the last 30 years she manufactured 16,000,000 tons, 9,000,000 of which was railroad iron, and that up to date she had not produced 16,000,000 tons.

The cost of iron is based on these facts: it requires 38 to 46 cwt. of ore, 30 to 50 cwt. of fuel, 12 to 18 cwt. of flux, with 13 tons of air blown in, with all the labor to produce the same, to make 1 ton of iron. Mr. Trueman, C. E., author of "British Iron Manufactures," says of cast iron: "The property of the greatest importance is tenacity, and is a quality of the first, if not of paramount importance. Transverse strength next, and is directly dependent on the tenacity of the metal, also power to resist impact, do. fatigue, do., crushing forces, hardness and texture."

Look at our development from decade to decade, prior to the introduction of the steam-engine, and from that to the introduction of railroads, and from that to this date, and you will see that since the introduction of railroads we have increased twofold in population, and fourfold in productions in per cent. over former decades. And our country is not one-half developed east of the Mississippi river, by railroads, compared with the most prosperous States.

Our railroads in 1850 owned 8,539 miles, and

to-day own 52,500 miles; we then possessed one through route, viz., the New York Central, and that had to pay canal tolls for the privilege of carrying freight, which amounted for many years to a prohibition, and to-day we have, say, 12 through lines. And if the roads carry one-quarter of the tonnage that the New York and New England roads do per mile, which is 850 tons, they carry 44.625,000, which, at $1.50 per ton, is $66,937,500; and if they should carry equal to the Boston and Maine Railroad, it would amount to over six hundred billion of dollars, and in 1900 A. D. will amount to threefold that amount.

These roads have been created chiefly by men who were not practical, and were, therefore, built at a great cost, as building and equipping railroads was a new business. The rails were made chiefly from inferior iron, known as the American brand, which has sacrificed much life and property, and in many cases, the roads themselves. State taxes were levied by New Jersey, Maryland, Pennsylvania, and other States, on passengers and tonnage. In the face of these obstacles we have attained our present wonderful development.

Manufactured in 1868.	Tons.	Value.
Foundry iron	575,000	$22,425,000
Hammered do	22,000	3,960,000
Boiler plate	111,462	15,047,370
Railroad iron	506,714	34,384,148
Bar, rod, hoop, axle and other rolled iron	337,828	35,048,850
Total	1,553,004	110,860.368
Bessemer steel	8,500	850,000
Cast and puddled steel	21,500	4,300,000
Total	30,000	5,150,000
Nails and spikes	149,000	16,390,000
Imported in 1868.		
Steel, ingots, bars sheet wire		1,705,337
Manufactured iron and steel		8,728,955
Railroad iron	228,277	4,781,575
Total	228,277	15,205,867
Domestic manufactured	1,553,004	110,865,368
Total	1,781,281	126,081,251
Domestic manufactured Bessemer cast and puddled steel	30,000	5,150,000
Total	1,811,281	131,231,251
Domestic manufactured nails and spikes	149,000	16,390,000
Total	1,960,281	$147,621,251

If iron has done so much for us as a nation, and must continue to do for us, at the rate of $600,-000,000, in 1900 A. D., have we done our duty to it? Certainly not; for we are making our iron much inferior to that made before this great development, and make it from the best ore in the world. We are growing poorer yearly, even if the quality of our iron remain the same, as we exact greater burdens from it than it can bear, caused by the development of the country over a larger area, which demands higher rates of speed and heavier and longer trains of all our railroads.

We now know that we have laid in the 52,500 miles of railroads 4,725,000 tons, which every 10 years must be re-rolled, based on English railroads (but when based on some of the best railroads in the United States, every 4 years, based on 5 years' experience), which (472,500 tons annually, at $75 per ton), is $35,000,000, and that this 10 per cent. is worn and

By oxidation lost	$3,500,000
And a further cost in car wheels of	1,250,000
And will lose to re-roll some $25 per ton	11,812,125
Annual loss to the railroads	$16,562,125

This loss in car wheels is based on their lasting 5 years, instead 2-31, as they do on New York roads, viz., passenger, 1-58, freight, 3-04, and they carry a weight per wheel: passenger, 3½ tons; freight, 1.47 tons, and allow one-half for old wheels. In 1900 A. D. the annual loss will be threefold—$16,562,125—based on population, and will double that based on production of other articles of iron, making a total loss of wear of iron to the nation of between $100,000,000 and $200,000,000 annually. And this loss is made when we own the best ore in the world, caused by several reasons, chiefly by the purchasers demanding a cheap iron, not knowing the value of iron, excepting as based on price, and the competition of the manufacturers against each other.

Of 17 cannons which were made for the United States from hot blast charcoal iron, 8 failed to stand the test. Cast-iron increases in strength from 403 lbs. on the first melting, to 725 lbs. on the 12th melting; bars 1 in. by 4 ft., and of cold blast charcoal pig-iron.

Mr. Mallet says of forgings 24 to 36 in. in diameter, "that they are liable to one or more rents, and have been found 18 ins. long, ¾ wide in the centre, caused by contraction after leaving the hammer. Again, the iron decreases in strength from the long exposure to the intense heat necessary, without the possibility of restoring the fibre by hammering. Again, hammer hardening, especially cold hammering, produced by making finished work or to give the form demanded to save cost of turning or planing, will produce crystallization and impair the iron.

We find the	Density.	Tenacity.	Comp. Strength. per sq. in.
Cast iron, least	6.900	9.000	84.529
" greatest	7.400	47.000	174.120
Wrought iron, least	7.704	38.027	40.000
" " greatest	7.858	74.592	127.720
Steel, least	7.029	60.000	198.000
" greatest	7.862	128.000	391.905
Baur or chrome steel, greatest		186.000	

Baur or chrome steel is not only one-third stronger than any other steel, but can be produced at small cost, from the fact that when worn out, as in a steel headed rail, it has a market value, as it can be made over again, which is not the case with Bessemer or any other cast steel. It will also weld without borax or flux, and when burnt can be redeemed on the next heat.

Seeing such facts, must not abandon iron for many purposes, by converting it into Baur steel, to enable us to develop the resources of our country at a low cost, for the cheaper we can do it, the more we can develop it, and through railroads we must do it. The 52,500 miles of roads cost $350,-

000,000. If they were all steel rails they would cost \$600,000,000; this great expense of \$250,-000,000 the roads would not bear even if it were practicable, which it is not, on account of the extreme winters; therefore we want a rail with the toughness of iron and the hardness of steel, which can be produced in a steel headed rail.

The present cost of re-rolling the 10 per cent. of nails annually re-rolled, with the loss from wear and oxidation, is	\$15,312,125
Cost to make these rails steel-headed, carrying 1.5 Baur steel, 472,500 tons, and \$25 extra	\$11,837,500

Which would wear as long as six iron rails.

This estimate of value does not include the extra expense of setting the rails in either case, which will give a still greater saving in favor of the steel-headed rail. From these combined facts we think the consumption of steel must increase.

We shall make 10 per cent. of all the railroad rails and car wheels	\$16,562,125
Reduce the importation of rails ½	2,390,787
Reduce the importation of steel ½	852,669
Reduce the importation of articles made of steel and iron ½	4,369,476
Also use cast steel for all large castings and forging, as the increased development of our country increases the drawing burden, and that increases the wear of the rolling stock of railroads, engines, steamers, etc., and said weight can be reduced full one-third, and diameter of bearings one-half, which will reduce the friction, and we can therefore depend upon one-tenth of our castings and forging being of steel. (The steamship companies will endorse this, as many lines lose 1 or more shafts annually.)	7,648,122
	\$31,823,180
And in A. D. 1900, must be about	100,000,000
Instead of, as in 1868	5,150,000

RAILWAY NOTES.

A New Railway Connection between the East and the West.—It is well known that the deficiency of railway connection outward from Chicago causes, at certain seasons of the year, a blockade of transit across the State of Michigan. There are, in fact, but two trunk lines, with some auxiliary connections that do not add much to their efficiency, to bring eastward from Chicago, the vast product of the North-west designed for the New York market. When we say the New York market we mean its demand for export as well as for consumption. The two existing trunks are the Michigan Central and the Michigan Southern, both of which are overladen with freight and travel every day in the year, and do not answer the actual requirement demanded by the North-west. In fact, the usual order of things is reversed on this latitude of transport. Instead of the railways seeking freight, and drumming for it, a vast surplus of freight is all the time drumming for passage. In this state of things, it is gratifying to announce that a new main trunk line is now in process of construction. the capacity of which will be equal to that of either the Michigan Central or Southern. Beginning at the joint terminus of the Grand Trunk and Great Western lines of Canada, it goes westward to Flint, and thence south-west to South Bend, a distance in all of 220 miles, of which the grading, bridging and road bed are finished, and some 65 or 70 miles, that is nearly one-third of the way, is actually completed and running. The remaining portion, from South Bend to Chicago, will be prosecuted with vigor. There is not a more needed work in progress, nor one that promises to pay a better profit. The line, composed of several sections, is known by the name of The Port Huron and Chicago Railway Line.—*Iron Age.*

Illinois Central Railway Locomotive Report for December, 1869.

December, 1869.	Chic. Div.	South Div.	North Div.	Iowa Div.	Total.
Miles of road	252.5	230.75	225.0	231.0	939.25
Miles Run:					
By passenger trains	34.832	34.101	26,673	13,753	109.434
By freight trains	107,515	63.197	111,434	45,753	327,902
By other trains	29.586	11,309	11,662	5.650	58,127
Total miles run	171,485	109,467	149,764	65,167	445,883
Running Expenses:					
Pounds of waste used	2,426	1,645	2.117	867	7,049
Gallons of oil used	1,660	1,020	1,423	582	4,686
Cords of wood used	267	57	81	46	450
Tons of coal used	5,191	3.118	4,919	1,976	15,205
Cost of wages	\$10,441	\$6,304	\$8,999	\$3.600	\$29,244
Cost of repairs	24,273	11.876	13,771	3,938	53,459
Cost of fuel	14,886	8,193	12,865	5,260	41,165
Cost of cleaning engines	2,326	1,260	1,167	699	5,458
Total cost	53,846	28,499	36,874	13,977	133,196
Cost per Mile Run:					
For oil, waste and tallow, cts	0.79	.79	.78	.73	.77
For repairs, cts	14.50	10.85	8.53	6.64	10.78
For fuel, cts	8.65	7.48	8.59	8.07	8.30
For wages, cts	6.06	5.76	5.94	5.52	5.89
For cleaning, cts	1.35	1.15	0.78	1.07	1 10
Total, cts	31.40	26.03	24.62	21.44	26.34
Average Miles Run.					
To one cord of wood	......	.....	......	......	......
To one ton of coal	33.01	31.89	30.45	32.25	32.25
To one pint of oil	12.41	13.41	13.15	14.00	13.23
Average number of cars per train	15.20	11.56	13.26	12.31	13.08

The above oil includes that used in head-lights and in lamps of engineers; wood is rated at \$7.00 per cord, and coal at \$2.50 per ton, loaded on tenders; oil 60 cents per gallon; waste 15 cents. per pound. Re-building, superintending, teaming, and all other expenditures relating to repairs, are included in the above cost of the performance of locomotives. Two empty cars are rated as one loaded. Whole number of engines owned by the company, 177. Average cost per mile, in cents, for

Passenger engines	20.74
Freight "	29.05
Construction "	24.20
Switching "	17.73

Samuel J. Hayes, Superintendent of Machinery.
—*American Railway Times.*

AMERICAN RAILROADS.—The growth of the railroad system in this country is shown by the following table:

Year.	No. Miles.	Increase.
1835	1,098	....
1836	1,273	175
1837	1,497	224
1838	1,913	416
1839	2,302	389
1840	2,818	516
1841	3,535	717
1842	4,026	491
1843	4,185	159
1844	4,377	192
1845	4,633	256
1846	4,930	297
1847	5,599	669
1848	5,996	397
1849	7,365	1,369
1850	9,021	1,656
1851	10,982	1,961
1852	12,908	1,926
1853	15,360	2,452
1854	16,720	1,360
1855	18,374	1,654
1856	22,017	3,643
1857	24,508	2,491
1858	26,968	2,460
1859	28,789	1,821
1860	30,635	1,846
1861	31,256	621
1862	32,120	864
1863	33,170	1,050
1864	33,908	738
1865	35,085	1,177
1866	36,827	1,742
1867	39,276	2,449
1868	42,255	2,979
1869 (estimated).	50,000	7,745

It thus appears that the number of miles of railroad constructed in this country during the year which has just closed is equal to all that existed up to 1849, and exceeds the total construction of any two former years. On this exhibit the "New York Tribune" remarks as follows:

"The 7,745 miles built in 1869 must have cost at least $300,000,000 (which would not be quite $40.000 per mile; and the cost of our railroads and their equipment averages more than that sum). Is it a wonder that we fall in debt to Europe?

"Of course we need railroads, and must build them. We shall probably have 100,000 miles in operation before the close of this century. But we cannot build all we need next year; and there must be a pull-up, or another 1837 will be down upon us. Gentlemen who are intent on more railroads! be good enough not to start any till after 1870, and let us try to fund our national debt!"

Under wise legislation which would equalize our foreign trade and expand our currency only as business expands, the country could extend her railroad system as rapidly as she requires it without running much into debt abroad. But it would have to be accomplished under different legislation from what the "Tribune" recommends.—*The Miner's Journal and Coal Statistical Register.*

THE GREAT LUXEMBOURG RAILWAY.—SIR,—I have had my attention called to your report of the meeting of this company, in which the chairman, Mr. W. Fenton, is stated to have said, in answer to the inquiry of an honorable shareholder respecting the "Fairlie engines," that he had asked, and I had refused to build an engine on their terms, but that I had made a counter-proposition which they could not accept, as they "would not be justified in making any experiments at the cost of the company." Will you kindly permit me a little space to state the facts?

Mr. Fenton asked me to supply an engine, and place it on his line in Belgium free of cost to the company, and that if the engine "should prove to be a success," of which he was to be the judge, I should be paid for it. I replied, situated as I then was, having already spent a fortune in illustrating and proving the value of the principle, I could not afford to accept the terms of the proposition as put; but I suggested that the company should advance me the money to build and deliver an engine on their line, and that if it did not do the stipulated duty I would undertake to remove it, and return every shilling advanced to me. I further stated that although I had not ready money sufficient to build an engine at my own cost, yet in the event of failure I would be prepared to guarantee the return of the money. I am willing to carry out this proposition, and will undertake to place engines on the Great Luxembourg Railway that shall enable that line to carry nearly double its present traffic, at a very large reduction in the cost of haulage per ton; thus permitting a considerable reduction in its tariff, whilst at the same time the engines should not damage themselves or "murder the rails" to anything like the extent that is now done with the ordinary engines. I know that the attention of the locomotive superintendent of the Great Luxembourg Railway was pointedly called a short time ago to my system, by a gentleman who thoroughly believed in it, and for whom he had been asked to design certain engines; nevertheless, he put aside that gentleman's recommendation, and designed the engines on a plan wholly different from mine. Such a fact will indicate the opposition my engine would encounter on the Great Luxembourg Railway, yet I am willing to face all this and take my chance. I am Sir, your obedient servant,

ROBERT F. FAIRLIE.

9, Victoria Chambers, Westminster, March 16.
—*Railway News.*

NEW COUPLING FOR RAILWAY WAGONS.—There is no feature in railway history more distressing than the dangers to which a humble but most useful class of servants are exposed in goods station duty, and numerous plans have been invented to obviate the necessity of men passing in between the wagons in shunting. It is perhaps true that many men get hurt by their own carelessness, and the accidents may be individually small. But they make up a large total of suffering and loss, and there is, we are sure, no manager or board that would not gladly adopt any reasonable means to prevent them. We have had an opportunity of inspecting a coupling invented by Mr. James Mackenzie, a gentleman in the service of the North British Company, which appears well suited to attain the end in view, and at moderate expense. The latter is, indeed, the main consideration, for the accidents cost money, and if a plan could be introduced which would cost less for interest on the expenditure necessary for its adoption, we think it would be received with general favor. Mr.

Mackenzie's plan, which has been tried practically in presence of his board of directors, possesses four excellent qualifications. It is—(1) simple in character; (2) requires no alteration in the present style of hook-and-chain coupling; (3) it can be used on any wagon, whether the one next it has the same fitting or not; and (4) its use is not affected by different height in the wagons or different length of buffers. It possesses the further merit of cheapness, the cost per wagon to fit both ends being estimated at 15s., and the inventor states it can be applied to any existing wagon in a quarter of an hour. As a matter of course, the system would save *time*, as the coupling or uncoupling can be done much more rapidly than by the present mode. The invention consists in the first place of two parallel rods, hanging from the wagon at the sides of the coupling-hook. A transverse rod works in rings which form the end of the two first rods. From this cross rod two projectors run parallel with the lowest link of the coupling chain, and grasp the link by two sliding catches. The cross rod is produced beyond the sides of the wagon, and is bent at each end into an angle, like the letter L. The action of the rods is exactly similar to that of the human arm, the first pair of rods representing the shoulder-joint, and the play of the cross rod giving the elbow action. Grasping the rod at the side of the wagon by the heel and the point, the porter first raises the coupling-chain by raising the rod, and then by pressing on the lever furnished by the projecting limb, the lower link of the coupling-chain is moved with an action exactly like that of the elbow-joint. Without a diagram it is not easy to convey an adequate idea of the extreme simplicity of the invention, but having seen it in operation, we can state that its action is exceedingly natural, and is likely in practice to prove satisfactory. Mr. Mackenzie's invention is to be submitted to the Royal Society of Arts at Edinburgh on Monday evening, when the inventor will personally describe it, and exhibit a working model.

ORDNANCE AND NAVAL NOTES.

Ironclads, Present and Future.—A lecture on this interesting and important subject was delivered last Monday evening at the Royal United Service Institution, by Mr. Charles F. Henwood, who possesses, as is well known, a large experience in designing and building iron armored plated ships. Mr. Henwood showed that the 47 ironclads which comprise our entire navy, and which have been divided into thirteen classes by the present Admiralty, are so various in their speeds, their sail-power, their handiness, and offensive and defensive power, that they are incapable of being combined for maximum uniform operations. This is clearly shown by the fact of there being 13 classes in 47 vessels. The importance of uniformity cannot be overestimated. Sir William Fairbairn has stated that "it is essential that the steam navy of this country should have great command of power, to enable the ships to manœuvre at sea with the precision of a squadron on parade." And Captain Selwyn says, "If you do not give us the highest speed attainable by any man-of-war afloat in the world you take from the navy the power of catching that man-of-war—and practically, whether your ship costs £1,000 or £1,000,000, if they cannot do the work they are sent out to do, the money had better not have been spent." The defects of the Audacious class, of which 6 are building, before one has been tried, were severely criticised; and it was shown that, although the Hercules is very strong at about the water-line, the armor protection of the fighting part of the ship was very inferior, being only plated with 5 in. in thickness. The defensive powers of the Monarch were incapable of resisting shot from similar guns to her own; in this respect the Captain was but slightly superior, but on the whole more completely defended than either Hercules or Monarch. The Captain, although only designed to compete with the Bellerophon, compares vrey favorably with those vessels as follows:

	Hercules.	Monarch.	Captain.
Length	325 ft.	330 ft.	320 ft.
Breadth	59 ft.	57½ ft.	53¼ ft.
Displacement	8530 tons.	8164 tons.	7650 tons.
H. P. (nominal).......	1200	1100	900
Speed, in knots......	14.69	14.9	14.32
Number and calibre of guns...............	8 400-pr. 2 250-pr. 2 115-pr.	4 600-pr. 2 115-pr.	4 600-pr. 2 115-pr.
Weight of broadside..	280 lbs.	2515 lbs.	2515 lbs.
Tonnage	5234	5102	4272

Taking the cost per ton, and per horse-power to be the same in all three cases, the Captain will have cost £62,800 less than the Monarch, and £77,220 less than the Hercules. The Captain, therefore, takes her place at the head of all our sea-going ironclads as being the most powerful, and at the same time most economical; and it is to a private shipbuilding firm in conjunction with Captain Coles, that the country is indebted for this highly satisfactory result; it is true we have yet to learn their comparative sea-going qualities, but there is no reason to doubt that the Captain will not, at least, equal either the Hercules or Monarch. The Devastation and Thunderer, turret ships, without masts and sails, are only estimated to have a speed of 12½ knots. This was a very serious defect in the days of high average speeds obtained by our Transatlantic steamships, and the high economical speed of our earliest ironclads. Moreover, the Admiralty had practically condemned these vessels, even before the second has been laid down, by proposing to build the third of this novel class of vessel of larger dimensions, horse-power, and higher speed. These three purely experimental vessels will cost the country about £1,000,000 sterling, whereas, in another and simpler way, we might obtain practically as efficient vessels for about one-third the money, by converting the best of our screw line-of-battle ships in the manner described in "The Engineer," February 4th, 1870. Considering that, in a few years, more powerful guns will be produced (for the Russian Government already possess 50-ton guns, firing shots 1120 lbs. weight with 130 lbs. charge of powder, one of which has been fired over 300 times), and that the zincking of ship's bottoms, and liquid fuel for generating steam, are still unsolved problems, which may involve another reconstruction of our navy, it would be a wise economy to adopt Mr. Henwood's proposal, for thereby, not only should we obtain practically as good vessels at one third the cost, but a portion of the money thus saved might,

with advantage to the country, be expended in making judicious and exhaustive experiments for solving these questions; and so should we obtain real economy with efficiency and advance in the true path of progress.—*The Engineer.*

The Hotspur.—On Saturday afternoon there was launched from the Govan shipbuilding-yard of Messrs. Robert Napier & Son, Glasgow, a screw armor-clad ram, built for the British Government, and named the Hotspur. The dimensions are as follows: Length between the perpendiculars, 235 ft.; breadth, 50 ft.; depth in hold, 20 ft. 1 in.; burden, 2,637 18-94 tons, builder's measurement; and 600-horse power. This war-ship is constructed on a principle that is entirely new in this country, but which was adopted some time ago in connection with the navy of France. Its chief features are the formation of a fixed tower or turret, the breastwork of which is 8 in. thick, and an immense ram forward. The diameter of the turret, which is pear-shaped, is 31 ft. 6 in., and 35 ft. 9 in. from the aft to the fore side. This stationary turret is armed with a 30-ton gun, carrying 600 lbs. of shot. It is worked on a revolving turn-table, the diameter of which is 26 ft.; from the two front portholes the gun has a training of 69 deg., and at the side portholes a training of 4½ deg. aft, and 26 deg. forward, so that it is able to fire right forward, and almost, but not quite, right aft. The gun can be elevated 12½ deg. and depressed 7, the recoil being 6 ft. 3 in. The ram projects about 9 ft. below water, and is brought up to a sharp point at a depth of about 8 ft. below the water-line. There are three decks, the middle one being plated with two thicknesses of iron tapered forward and aft. The engines, which have been made and fitted by the Messrs. Napier, are of the direct-acting horizontal description, having two piston-rods to each cylinder, and are fitted with surface-condensers and all the most recent improvements. The boilers, of which there are four, are of the ordinary tubular type, with five furnaces each. The propellers are 11 ft. in diameter, on Griffiths' plan, with movable blades. In all, six armor-clads have been built by the Messrs. Napier for the British Navy. In 1856 they set afloat the Erebus, in 1861 the Black Prince, in 1862 the Hector, in 1869 the Audacious and Invincible, and now the Hotspur.—*Mechanic's Magazine.*

Lifeship.—Capt. Hans Busk exhibited at the *conversazione* of the Royal Society on the 5th inst. a model of a steam lifeship, which he offers as likely to render good service where the lifeboat fails. The lifeship with a crew of thirty men is to keep the sea, and in case of falling in with a vessel in distress, would render assistance from the windward, which would be easier, and often more effectual, than when borne from the leeward in the teeth of a gale by a lifeboat. The lifeship could "warp down" a boat to a helpless vessel, or, approaching near and dropping anchor, could fire a rocket and send a line with the wind, and so establish communication.

The Invincible.—The new double-screw iron ship, iron-plated, Invincible, 14,1 recently brought from Glasgow to Plymouth, made a preliminary trial of her machinery on Saturday, when she ran from Penlee Point to the Eddystone and back with a satisfactory result.

ENGINEERING STRUCTURES.

The Bulging of Walls—Cause and Prevention.—The ugly protruding curvature commonly called a bulge, to which external and front walls seem especially subject, may frequently be traced to original defects of construction. Bulges may often occur at about the level of a floor, and where there is a floor, the brick-work of outer walls is commonly weakest. To avoid running the floor-timbers into party wall, they are generally made to rest on the front and back, and the party wall will often appear in better condition than the front. Immediately below the level of the intended floor, a timber scantling about 4½ in. by 3 in. is laid along the wall flush with its inner face, to receive the ends of the joists. The joists, let it be assumed, are about 10 in. deep, notched to 9 in. at the ends, so as to rise the height of three courses of brick wall. Here, then, bond-timber and joists together make a height of 12 in., or four courses of brick-work. The joists will have a bearing of 6 in. on the wall, and the wall may be supposed to be a brick and a half thick. Now, wherever the joists occur, there is a complete interruption of the bond on the inner side of the work, while externally it appears unbroken, the outer face, in fact, being carried up half a brick in thickness, and looking as though the whole wall were perfectly solid and uniform; but the backing between the timbers too often consists of bats and small pieces put together in a mysterious though incongruous way. So long as the timber remains sound and of its full dimensions, all is well, but this is seldom very long. The manner of converting balk-timber in scantlings precludes the permanent retention of its original form. When felled and squared in its native forests, it is thrown into the first lake or river, formed into rafts, and navigated into some port of shipment, where it is formed into cargoes for conveyance across the ocean. The sea voyage over, it may be assumed to the port of London, the timber is again immersed in water, which usually constitutes its only place of storage till wanted for actual application to some building. As to deals, an architect may specify dryness as a necessary quality, but he must not expect it in timber. He may say that it shall be sound and well seasoned, but water-seasoning is all that takes place previous to conversion, and this fact is noteworthy, because as the subsequent shrinkage may be estimated at three-quarters of an inch in the foot, it becomes obvious that so far as the bond-timber and joists are to be regarded as forming the inner material of the wall, a subsidence equal to the shrinkage must take place. But the wall does not depend on the wood-work alone, and the irregular filling up between the joists will receive the weight, and so evil will be deferred. For the time there may be no other visible result than the dropping of the floor from the skirting, and when the latter is of wood, the simultaneous rising of the skirting from the floor. It is when the wooden bond, having shrunk to the minimum dimension of perfect dryness, enters upon its course of decay, that the worst consequences of inserting timber constructionally in walls are developed. The inner face then sinks, and the statical conditions are disturbed, and bulging is inevitable.

It was the custom of bygone days to insert timber very freely in walls. Foundations were fortified, as it was thought, by the introduction of a

"chain-bond" of large scantling, and many a goodly edifice has suffered from the practice. Great, therefore, have been the improvements adopted in the modern construction of walls. A solid basis is formed by the use of concrete; wrought iron hooping has advantageously displaced wooden bond, and the joists are kept as much as possible out of the walls, their ends being supported by brick or iron corbels. Thus all rapidly perishable matters are excluded, and a lasting character imparted to work so executed. Skirtings also are made of stucco instead of wood, and shrinkage in that quarter got rid of. Thus experience and science are gradually removing one of the old defects and disfigurements of buildings—the bulging of walls.—*Building News.*

THE BRIDGE TO CONNECT PHILADELPHIA WITH CAMDEN.—It is stated that the stock of the Philadelphia and Camden Bridge Company has all been taken, that the plan of the structure has been adopted, and that the work will shortly be undertaken and pushed forward with all convenient speed. The construction of great bridges is the prominent feature of engineering work at the present time. At St. Louis and at Brooklyn immense caissons of iron have been made for foundations in piers at a great depth, and something of the same kind will be needed for the great viaduct across the Delaware. One of the admirable features of this work will be the arrangement of the draw, by which ships may be passed without any serious impediment to travel on the bridge. The track will be divided at this part of the bridge, so that one part may be open for the passage of a vessel, while cars and vehicles are crossing on the other, and the first part closed when the second is opened. Steamers and small sail-vessels will pass under the span of the bridge which will be over the main channel, at such a height as to form no obstacle to their movements.

The completion of this work will wonderfully stimulate improvement in Camden and its vicinity. The business portion of Philadelphia is near the Delaware, and this bridge will practically bring Camden nearer to it than the outer parts of the consolidated city now are. Passenger railways, using dummy engines, will radiate from the eastern end of the bridge, and the country within a radius of ten miles will be but half an hour's ride from Market and Second streets in Philadelphia. The increase in the value of real estate in a few years will pay the cost of the bridge three times over.—*Philadelphia Underwriter.*

NEW BOOKS.

A HAND-BOOK OF PRACTICAL TELEGRAPHY. By R. S. CULLEY. Fourth edition, revised and enlarged. Published by D. Van Nostrand.

The first appearance of Mr. Culley's "Handbook of Practical Telegraphy," in 1863, inaugurated a new era in telegraphic literature. Although of small size, and written in a simple and unpretending style, it contained more common sense and more practical information than all the previous works which had appeared in the English language combined. Although not faultless, in a scientific point of view, yet it was so far in advance of all its predecessors, and supplied such an obvious and long felt desideratum, that it was gratefully received by a large class of eager students of electrical science, who, for the first time, were enabled to avail themselves of that technical knowledge of the laws of electricity, and its practical application, before attainable only through verbal instruction, or the tedious school of actual experience. Since that time the labors in this field have been enlarged and extended by the publication of such works as those of Clark, Sabine, and Pope, which, though differing widely from each other in their mode of treatment of the subject, are all characterized by the distinctively practical character of which Mr. Culley in his work was the first to set the example. During this time, however, the author of the "Hand-book" has not been idle, but has kept pace in successive editions, with the rapid development of electrical science, which has been such a marked characteristic of the past decade.

The fourth edition, which now lies before us, is nearly double the size of the original work, and in addition to the new matter which has been incorporated with it, the older portion has been revised and re-written. The volume, as a whole, is a credit both to the author and the publisher.

The first part of the work treats of "Sources of Electricity." A lucid and correct explanation is given of the theory of the action of batteries, supplemented with descriptions of the different kinds, and useful directions for their maintenance and management. In the introduction it is stated that the Daniell battery is used by the three great telegraph companies of England, now merged into one system and under government control. The form most generally employed is an oblong box or trough, divided into five cells, with flat plates of zinc and copper, about four inches square, instead of placing each couple in a separate cylindrical tumbler, as is usually done in this country. The English arrangement is convenient, cheap, and economical of space.

The Leclauche battery, recently introduced, is described, and appears to give good satisfaction. the electro-motive force is equal to 1.6 that of Daniell, with much less internal resistance; but when placed in short circuit it polarizes very quickly, and it, therefore, cannot be used for permanent currents nor as a local battery. Mr. Culley says that the Marie Davy, or sulphate of mercury battery, is almost exclusively employed at the Central office of the French Administration of Telegraphs in Paris.

Mr. Culley devotes a chapter to the important subject of insulation, in which this matter is more fully treated of than is usual in works of this class. In describing the qualities desirable in an insulator for telegraph lines, he says: "The best insulator is that which has the smallest possible diameter consonant with strength, with the greatest distance between the wire and the bolt or support, and which can be maintained in the driest condition in wet weather, while exposed freely as regards its outer surface to the cleansing action of rain." This is a concise and correct statement in the main, but we think Mr. Culley overrates the beneficial effect arising from the cleansing of the insulators by exposure to rain. In wet weather the outer surface will conduct, whether clean or otherwise. Of course, a clean surface helps to insulate the line in fine weather, when help is least needed; but if a circuit can be so insulated as to work well in wet weather there will be no trouble at other times. This result may be accomplished simply by prac-

tically carrying out the principles above laid down by Mr. Culley, which has been done to the fullest possible extent in the American paraffined insulator, invented by Brooks. A glass bottle, protected by an iron shield, is interposed between the wire-holder and the support, having a diameter of about an inch, and an insulating length of about 9 inches. This is kept dry in wet weather by the use of paraffine, as well as by its form and arrangement in regard to the pole and wire. Compare this with the ordinary glass insulator, having a diameter of two inches or more, and an insulating length of two inches, and the reason of the superiority of the first is apparent, leaving the paraffine out of the question.

We cordially endorse all that Mr. Culley says in regard to the periodical cleansing of insulators. To keep a telegraph line in thorough working order the insulators ought to be cleaned every year, whatever kind may be used. It seems exceedingly strange that people will build a telegraph line, and expect it to keep itself in order for ever afterwards, unless it actually falls down from decay. If they build a house they expect to paint it every three or four years; if they build a railroad they are continually at work repairing it, but if the insulation of a telegraph line becomes defective from the accumulation of years of dirt and neglect, there is no remedy but to throw all the insulators away and try some other kind, perhaps better, but quite as likely to be worse than the original variety. The pig-headed stupidity of the American telegraphic mind upon this subject would be irresistibly laughable were it not so humiliating.

The chapter on the construction of lines contains a great amount of useful advice; much of which, however, is more valuable to the English than to the American constructor. The latter, however, cannot fail to be benefited by a careful study of European methods, as they abound in valuable hints, which may be practically carried out to advantage in this country, though frequently by entirely different processes.

In the present edition the portion relating to submarine telegraphy has been re-written and enriched by the addition of a very large amount of new matter. The methods employed in testing the French Atlantic cable, during its manufacture and submersion, are very fully described and profusely illustrated, and the student of this interesting but abstruse and difficult branch of electrical science will find in this work his most valuable compendium. It is fully up with the most recent discoveries and investigations.

The work is rather scantily illustrated as a whole, and the cuts and diagrams are not remarkable for their artistic elegance, but otherwise the mechanical execution of the book is worthy of the highest praise. The type, printing, paper and binding, are all of the first quality. We are glad to note the rapidly increasing demand for books of this class, and can assure our readers that they will find this one of the very best of its kind.—*The Telegrapher.*

ANNUAL REPORT OF THE STATE GEOLOGIST OF NEW JERSEY, for 1869. 8vo, 57 pp. and map.

Professor George H. Cook, the State Geologist, gives a valuable report on the economic geology of New Jersey, and enriches it with several carefully drawn maps. It does not cost the State much to carry on such a survey, or to publish its results, while the benefit of disseminating the information is very great. The best way to develop the hidden resources of any country is to bring them out of their hiding places by well conducted geological surveys, and the State that shows the most zeal in this direction will reap the earlier returns of increased emigration.

WINSLOW'S COMPREHENSIVE MATHEMATICS: Being an extensive cabinet of numerical, arithmetical, and mathematical facts, tables, data, formulas, and practical rules for the general business man, merchant, mechanic, accountant, teachers of schools, etc. Eighth edition, revised and enlarged; 380 pp.; $2 50. Boston and New York: E. S. Winslow, 1870. For sale by Van Nostrand.

The tables, showing the values in American currency of the moneys of the different nations of the world, and the great variety of information about weights and measures here collected, make this book a valuable addition to the list of school text-books, as well as a convenient manual for the business man. Some of the more recent problems which have arisen in natural philosophy and chemical science are also taken up and treated in a way which may be easily understood by beginners.

NATHAN READ. HIS INVENTION OF THE MULTI-TUBULAR BOILER AND PORTABLE HIGH-PRESSURE ENGINE, AND DISCOVERY OF THE TRUE MODE OF APPLYING STEAM-POWER TO NAVIGATION AND RAILWAYS. By his friend and nephew, DAVID READ. New York: Hurd & Houghton. For sale by Van Nostrand.

This is an exceedingly interesting addition to the history of the application of the steam-engine to locomotion. Neither the steamboat nor the locomotive was successful until after the invention of the multi-tubular boiler. Mr. Read's claim to the original invention of this important adjunct to Watt's engines, is well set forth by the letters and sketches made as early as 1789.

The volume is a handsome book of 200 pages, illustrated by several wood-cuts.

ICE. A LECTURE DELIVERED BEFORE THE KESWICK LITERARY SOCIETY, and published by request; to which is appended a GEOLOGICAL DREAM OF SKIDDAW. By J. CLIFTON WARD, F. G. S. London: Trubner & Co. For sale by Van Nostrand.

The subjects treated in the lecture are:

1. Some of the physical properties of ice.
2. Ice considered as a natural agent.
3. The marks of ice action in the lake district of Cumberland pointing to a former condition of things, different from that now prevailing.

MEMOIRE SUR LE TELOMETRE A PRISMES. Par G. M. GOULIER. Paris. Libraire Militaire. For sale by Van Nostrand. The instrument described in this *mémoire* is a convenient addition to the outfit of military engineers, and might be made serviceable in the hands of civil engineers when conducting reconnoissances.

ELEMENTARY PRINCIPLES OF CARPENTRY.—A Treatise on the equilibrum of timber framing, the resistance of timber, and the construction of floors, centres, bridges, roofs, etc., etc. To which

is added an essay on the nature and properties of timber, etc. By THOMAS TREDGOLD. Fifth edition, corrected and considerably enlarged, with an appendix containing specimens of various ancient and modern roofs, by PETER BARLOW, F. R. S. London: Lockwood & Co. For sale by Van Nostrand.

There are but few names so familiar to students of the science of building as Tredgold. Its value to the practical architect is sufficiently attested by the demand which has called forth this new edition.

The number of plates has been increased over those of the former editions, by the illustration of some modern examples.

MEMOIRE SUR LE POINT OBSERVE ET LA DETERMINATION DES COURANTS A LA SURFACE DES MERS. Par A. FASCI, Professor d'Hydrographie. For sale by Van Nostrand.

This book of sixty pages is a good supplement to the better works on navigation. The first part is purely theoretic and abounds in mathematical formulas. The second part consists of practical problems worked out in illustrations of the formulas. Five folding plates, containing thirteen figures, illustrate the text.

A TREATISE ON MEDICAL ELECTRICITY, Theoretical and Practical, and its use in the Treatment of Paralysis, Neuralgia, and other diseases. By JULIUS ALTHAUS, M. D. London: Longmans, Green & Co. For sale by Van Nostrand.

This volume of 700 pages is divided into five chapters, which treat respectively upon: Forms of electricity; electro-physiology; medical electric apparatus and methods of applying electricity; electricity as a means of diagnosis, and electro-therapeutics.

The work is designed for the practising physician, and abounds in *cases* treated by the methods prescribed by the author.

NAUTICAL ASTRONOMY AND NAVIGATION. By H. W. JEANS, F. R. A. S. London: Longmans, Green, Reader and Dyer. For sale by Van Nostrand.

Part one, containing rules for finding the latitude and longitude, and the variation of the compass, with numerous examples. Part two, containing the investigations and proofs of the principal rules and corrections, with practical examples.

A TOPOGRAPHICAL MAP OF TREASURE HILL, White Pine County, Nevada. Compiled from actual survey by subscription of the principal mining companies and capitalists of the district. By WM. HAMMOND HALL and EDMUND F. DICKINS. New York: D. Van Nostrand.

CONSTITUTION DE LA MATIERE ET SES MOUVEMENTS. NATURE ET CAUSE DE LA PESANTEUR. Par LE P. LERAY. Paris: Au Bureau du Journal Des Mondes. For sale by Van Nostrand.

LA LUMIERE ELECTRIQUE APPLIQUEE A LA NAVIGATION. Paris: Libraire Maritime et Scientifique. For sale by Van Nostrand.

MISCELLANEOUS.

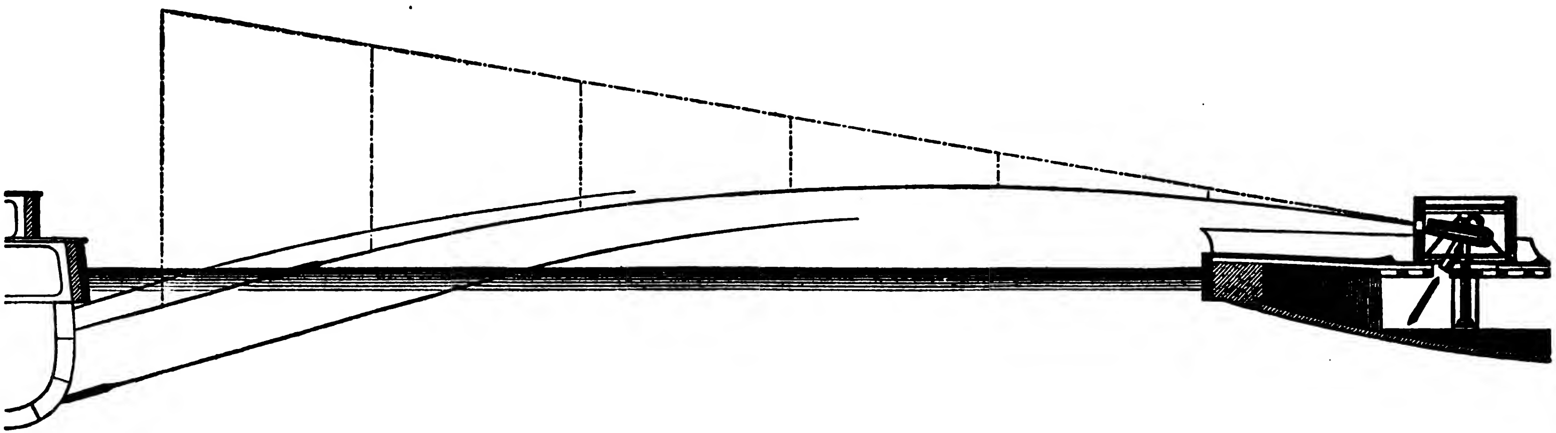
THE VALUE OF INVENTIONS.—In one of the Lowell Institute lectures, lately delivered in Boston, the speaker, General Samuel A. Duncan, made mention of some notable examples of the value to the world of patented improvements, as follows: "The expenses of the Patent Office up to the present time have been $5,583,337.35, to which, if there be added the cost of the building itself, and the money expended upon the annual reports, the entire sum will reach perhaps $12,000,000. But what is this compared to the benefit derived by the public from a single invention of real importance? There are, perhaps, 400,000 sewing-machines in use in the country. Ten cents a day would seem an absurdly low estimate of the value of each of these to its owner; and yet even *this* daily profit would make the aggregate annual sum to the community from this source alone $15,000,000. It is computed that the saving of grain by the use of thrashing-machines in place of the flail, which they have supplanted, is 10,000,000 bushels annually. It is the inevitable tendency of all improvements in the arts to cheapen production. Heathcoat's machines reduced the price of bobbin net lace from five guineas a yard to sixpence. The Bigelow looms for weaving ingrain carpets both reduced the cost of the manufactured article 20 per cent. and improved the quality of the goods. The cotton-gin reduced our price of raw cotton by stimulating the production so that it has increased in three years from 138,000 lbs. to 5,000,000 lbs."

MR. J. N. DOUGLASS recently read a paper on the Wolf Rock Lighthouse, before the Institution of Civil Engineers. He said that, when it was resolved to fit up for that lighthouse a revolving dioptric light, showing alternate flashes of red and white at half-minute intervals, the arrangement involved the consideration of the question of disposing in each beam the relative proportion of light to allow for the loss in red beams by passing through a ruby glass medium. The investigation of the subject was entered into by Professor Tyndall, the scientific adviser of the Trinity House; and as it was one which could not be determined with accuracy by photometric measurements, he, with the author, paid a visit to the Rock Lighthouse, near Liverpool, which had a catoptric revolving light showing one red flash succeeded by two of white at intervals of one minute, and inquiries and observations were made on this light at the Point of Air Lighthouse, at a distance of 11½ miles, and at the Great Ormes Head Lighthouse, at a distance of 30½ miles. Experiments with red and white lights were also made in the experimental lighthouse of the Trinity House at Blackwall, and observations on these were taken from a station in Charlton, at a distance of two miles. From these practical tests it was determined that the quantity of light to be appropriated to the red beam should be to that of the white in the ratio of 5275 to 2250, or as 21 to 9 nearly.

TREES IN CITIES.—Dr. Poselger has proven by experiments that the death of fine trees in cities is not due to the leakage of gas mains, as has often been asserted; and that no damage can accrue to the trees, nor their growth be interfered with, by any quantity of gas which may escape in the soil and find its way to their roots.—*Quarterly Journal of Science.*

CAPTAIN ERICSSON'S NEW SYSTEM OF SUBMARINE ATTACK.

SEE PAGE 635.



VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

NO. XVIII.—JUNE, 1870.—VOL. II.

EXPERIMENTS UPON FORGED IRON BEAMS.*

The first portion of this valuable paper was devoted to a description of an iron shield to an experimental casemate at Fort Monroe, with the result of some firings in October, 1868, at which time the shield was employed as a target.

The standards forming the backing to the target were wrought-iron uprights having a section of 12 by 15 in.

From the character and extent of the rupture under the heavy firing, it was impossible to estimate what amount of resistance the standards had really offered to bending or breaking. It was generally believed to have been much less than formula, founded upon assumed elastic extension of the fibres, would authorize us to assign them. Experienced iron manufacturers suggested that the highly crystalline appearance of the surfaces of fracture was caused by the instantaneousness of the rupture; others believed that it was common to *all* large forgings, and created during the slow cooling from welding heat; while still others attributed it to bad workmanship.

It was thought that it would be instructive to break one or more of these beams under the slow pressure of a hydraulic press. For that purpose, two were brought from Fort Monroe to the Brooklyn Navy Yard, one of which was the only sound one remaining in the casemate shield; the other came from the "open embrasure" target.

The composition of the iron, and its conversion into bars for forging, are thus described by the manufacturer:

* * * * * * *

"The iron was made of the following brands of pig-iron: Three-fourths Lake Superior charcoal, made by the Morgan Iron Company, at their old furnace near Marquette, Michigan. The blast, I suppose, ought to be called *warm*. The intensely hot blast now in use had not been introduced into that region at the time this iron was purchased, several years ago.

"The other one-fourth was of anthracite hot-blast iron, made at the Donegal furnace, in the Juniata region, Penn. I adopted this mixture of metals, as we found, after numerous trials of other irons, this to be the best for making blooms, of which to make galvanized iron. This requires a most superior iron, soft and malleable when cold. These qualities I judged were most desirable for armor plating.

* * * * * * *

"The pig-iron is converted into wrought-iron by the usual method of puddling or boiling—from the furnace taken to the squeezers and formed into a lump, and then at the same heat rolled into bars of ¾ in. to 1 in. in thickness, and 4, 6, and 8 in. wide.

* * * * * * *

* From a paper read before the American Society of Civil Engineers, February 7, 1870, by Brevet Major-General J. G. Barnard, U. S. Corps of Engineers, Member of the Society.

"The bars thus formed were forged together into the beams under a 4-ton moving cylinder (Condie) hammer falling 5 ft. 9 in."

* * * * * * *

The diagram and following table will give the facts of the first experiment:

* Flexure in inches.	Tons of 2,000 lbs. pressure.	
¼	430	
⅜	500	
½	553	
⅝	584	
¾	584	
⅞	597	
1	599.6	
1⅛	645	Two small cracks noticed on the face of the beam, at top, right of fulcrum.
1¼	645.8	
1⅜	645.8	
1½	661	
1⅝	676	
1¾	676	
1⅞	692	
1 15/16	707	
2	707	
2⅛	738	
2¼	753	
2½	769	
2¾	784	Broke across, as shown in sketch, the fracture being highly crystalline—the crystals being largest in the centre.
3	799	
3⅛	799.8	

The first recorded flexure of ¼ in. gives a calculated strain per square inch of the upper external fibres 36,792 lbs.; an elongation of the same of .00382; and a corresponding coefficient of elasticity of 9,558,600 lbs. (for inch unit).

The seventh entry in the table shows a flexure of one inch under a pressure of 600 tons.

The corresponding tension of outer fibre is......................	51,508 lbs.
The corresponding extension of outer fibre is..................	0.0154 "
The corresponding coefficient of elasticity is..................	3,334,511 "

The last entry but one shows a flexure of three inches under a pressure of 800 tons, for which we have:

Tension per square inch of outer fibres.........................	68,450 lbs.
Extension of outer fibres.........	0.0463 "
Corresponding coefficient of elasticity.........................	1,482,000 "

* The experiments were conducted by Brig.-Gen. C. B. Reese, U. S. Corps of Engineers.

The flexure of 3¼ inches produced rupture without any indication of increased pressure; and it will be observed that there are several stages in which the flexure thus increases. The press worked slowly—was frequently stopped (the whole time of experiment being 15 to 20 minutes), and when stopped the pressure became relaxed. On renewing it the flexure increased before the pressure gauge regained its lost elevation. Time had, *perhaps*, considerable to do in producing so great a flexure of the iron. Nevertheless, the strength of the iron is very great; and, for so large a beam, the extension of fibre is extraordinary.

The "permanent set" extended only 15 inches each way, from the place of fracture. At the limit of "set" the strain was equal to what would be produced at the middle point by a load of 400 tons, multiplied by $\frac{38.5-15}{3.85} = 242$ tons. This weight is about a mean between those required to produce deflexions of ¼ and ½ an inch. It corresponds to a strain on the external fibres of 41,391 lbs., and an elongation in .005. But a remarkable feature in the "permanent set" is exhibited in the *cross section*. The base is permanently expanded ½ an inch, while the top is contracted or shortened ⅛ of an inch, by which the section of fracture has acquired a trapezoidal figure; a strong collateral proof of the ductility and toughness of the iron.

It must be borne in mind, however, that the above calculations suppose that, at the same moment, the coefficient of elasticity is uniform throughout the beam. We see, however, that the coefficient rapidly diminishes as the extension increases, and hence it must be very much less in the more extended outer fibres than in those near the neutral axis. Moreover, it is probable that it does *not* so decrease for increased compression; and hence the neutral axis will fall below the middle of the beam. This last effect is indicated, too, by the change in the section; the area of the portion below the middle line becoming about 1/24 larger than that above it. The above figures for breaking tension must, from all these causes, be somewhat too high.

On the 25th of May the second beam was subjected to the same test. It was manufactured about six months earlier

than the one first described, but there is no known difference in the material or process of manufacture. The statement herewith, will give the particulars of the experiment. Though the breaking pressure proved to be identically the same as before, the flexure was but 1 inch instead of 3¼ inches. That is to say, the tensile strength was as before, 68,450 lbs. per square inch; but this corresponded to an "elongation" of fibre but 0.0154, while the coefficient of elasticity was 5,446,000 instead of 3,334,511 lbs., the coefficient furnished by a corresponding extension in the first beam. No "permanent set" either in figure or cross section was observed. In this case there was no stoppage of the force pump, and the power was applied as rapidly as possible, the rupture taking place in about 2½ minutes.

Flexure in inches.	Tons pressure (of 2,000 lbs.)	
½	615	
¼	707	
¾	767	
1 (short)	799	Broke across, as shown in sketch; the fracture being highly crystalline.

In this experiment the pressure was applied as rapidly as possible, and the beam broke in about 2½ minutes after commencing the experiment.

In all cases, whether the beams were broken by the intantaneous shock of the projectile, or by the comparatively slowly applied pressure of the press, the fracture was throughout highly crystalline. I do not think that there is any decided distinction between the results of the two processes. In the last beam broken the cleavage surface of the crystals was larger and the fracture more ragged than in the first. Around the outer margins of both, the fractured surfaces were much finer-grained (approximating in the first beam to the appearance of *very* coarse sand-paper) than at the central portions. The largest cleavage surfaces may be ⅛ to ¼ square inch in area—though such are rare. The second beam, more highly crystalline than the first, had less ductility (*i. e.*, was more brittle), yet its breaking strain was not impaired.

As the foregoing calculations could not, for the reasons stated, be implicitly relied on, it was important to determine the tensile strength by direct experiments. Two specimens were taken from each of the beams—one of which was heated and hammered, and drawn down to proper size—the others tested just as they came from the beam. (These last were taken from the central and most crystalline portion of the forgings.) The results are as follows:

			Tensile Strength.
No. 1. First beam, reworked specimen,			63 413 lbs.
No. 2. Second beam	"	"	67.846 "
No. 3. First beam, unworked		"	53.953 "
No. 4. Second beam	"	"	57.786 "

The fracture of No. 1 was what is called "fibrous," that is, fine-grained and dark, when looked at directly, but lustrous under certain lights, and what is usually considered as indicating a superior iron.

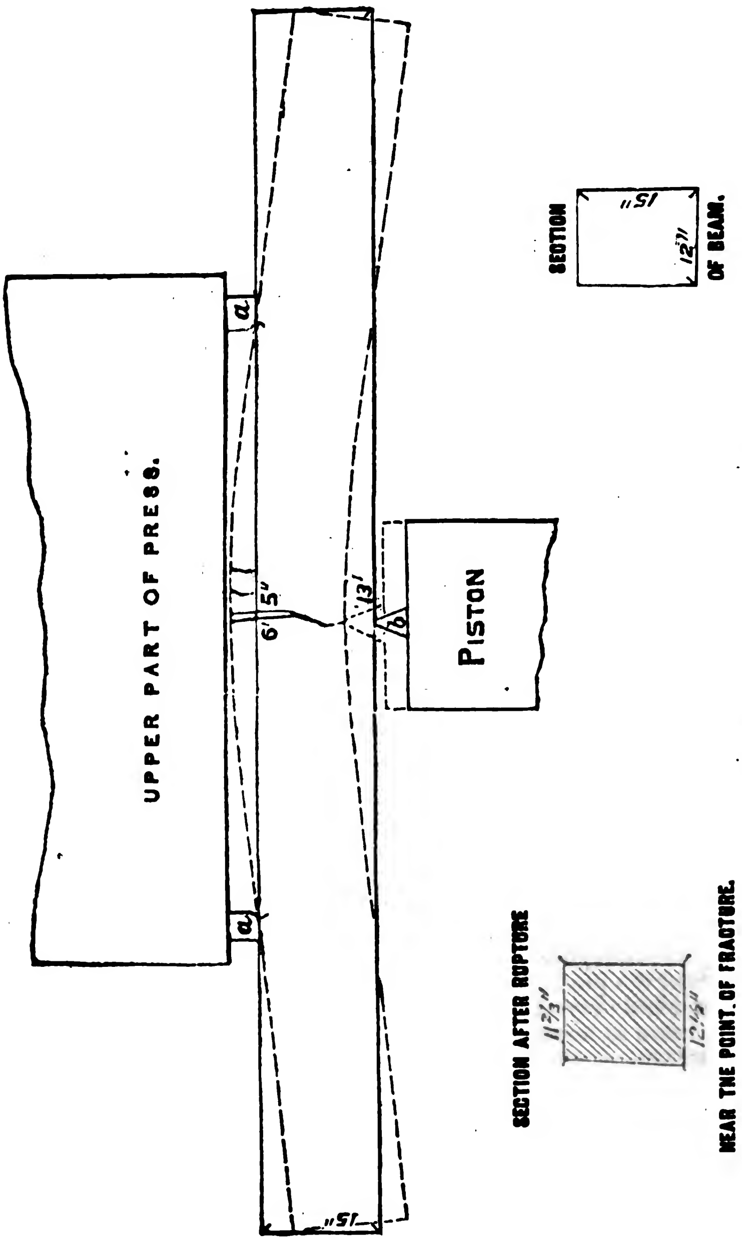
The central part of No. 2 (say about one-third) had the same appearance as No. 1, though inferior; all the rest, say two-thirds of the surface, was highly crystalline, and not finer-grained than *some parts* of the fracture of the original beam.

Of No. 3, the fracture was very similar to that of No. 1, though less lustrous.

The fracture of No. 4 exhibited over a segment comprising about one-third of the circular area, a fine-grained fracture, but darker, and destitute of lustre; the rest of the surface was highly crystalline, yet less coarsely grained, if there was a difference, than the crystalline parts of No. 3.

It is to be observed that the real tensile strength of the iron *in the beam* (as given in Nos. 3 and 4) was in the one case 20, in the other 15 per cent. less than that deduced from calculation; that the process of reworking gives about an equal increment in the two cases. The difference in the two beams may be owing to variations in the character of pig-iron coming from the same sources, or from varying time and heat in the forgings.

The tensile strength exhibited by these beams was above the *average* for wrought-iron in bars, while the reworked specimens are equal to the average of a large number of specimens of Burden iron, and approach in strength the best irons



a a, bearings of steel. *b*, piece of steel 1" wide on top.

Scale ¼" = 1 foot.

known, as will be seen from the following figures :

Major Wade gives (1845) strength of different irons thus :

Russian iron (in flat bars)...	62.644 lbs. per sq. in.	
Bankes' (English) ...	56.532	"
Low Moor " ...	56.103	"
Bridgewater (Am.) iron...	48.483 lbs. per sq. in.	
" "	49.338	"
Salisbury iron is given by Prof. W. R. Johnston at...	58.009	"
And charcoal refined Lake Superior at............	89.582	"

The Ordnance Manual gives for—

Bar iron.................	57.000 lbs. per sq. in.	
Salisbury iron............	57.000	"
Swedish iron.............	72.000	"

Kirkaldy says: The breaking strain per square inch of wrought-iron is generally stated to be about 25 tons for bars and 20 tons for plates. This corresponds very nearly with the writer's experiments, of which the following table presents a condensed summary :

	Highest.	Lowest.	Mean.
	Lbs.	Lbs.	Lbs.
188 bars, rolled............	68.848	44.584	57.555
72 angle-iron, etc............	63.715	37.909	54.729
167 plates, lengthways............	62.544	37.471	50.737
160 " crossways............	60.756	32.450	46.171

The extension, especially of the first beam (one-twentieth, nearly), though far beneath that sometimes exhibited by small rods or wires, is very remarkable, when the dimensions of the forgings and the highly crystalline structure of the iron are considered.

It is highly probable that so great extension of fibre as these experiments developed did not take place in the beams ruptured by the firings. Though identical with the experimental beams in composition and manner of fabric, not the slightest trace of "set," so strikingly exhibited by the first beam, could be observed in them. That the forgings were excellent may be inferred from the absence of appearances of seams or flaws in the fractures, and from the rupture occurring exactly at the middle point. The engineers and master mechanics of the Navy Yard, and other experienced operators in iron, regarded them as "of most excellent quality of workmanship, having the clearest and most solid appearance of any bars they had seen."

The results show neither high tensile strength nor a considerable ductility to be incompatible with the process of "forging" in large masses; and that iron of a highly crystalline structure (the usual result of such forging) may possess these qualities; that, in common with iron so prepared as to possess the maximum of ductility, it does not exhibit that quality to its full extent when the rupturing shock is instantaneous.

Hence the iron supports of shields should be of such a character (*e. g.* built-up beams) that the necessary yielding may take place by *warping* rather than extension of fibre; or, on the other haud, should be such as to involve *no extension whatever*—the target, by means of arched backing or something of the kind, being made perfectly rigid and the shot made to expend *all* its work, instead of at least nine-tenths (as it inevitably must do), *upon the indentation.*

On the 14th of August a beam of the sam dimensions, cast vertically, from the same pig-irons, in the same proportions, and allowed to remain in the mould until thoroughly cool, was broken in the press.

The results were as follows :

Flexure ½ in.,................Pressure, 183 tons.
" ¾ " .... " 276 "
At which flexure the beam broke.

From whence by calculation we should get for a flexure of ½ in. :
Tension per sq. in. of outer fibres,.....15.640 lbs.
Extension of fibre,....................00.382 "
And for a flexure of ¾ in.:
Tension of outer fibre (that of rupture) 23.615 lbs.
Extension of fibre...................... 00.53 "

A specimen of iron from this beam was tested for tensile strength and found to have 16.067 lbs., or about 33 per cent. less than deduced above.

It was believed that better results might be obtained, and the iron was remelted in a reverberatory furnace, 4½ hours being occupied in the melting, the casting remaining 3 days in the mould.

This recast beam broke with a pressure

of 384 tons, with a flexure of $\frac{5}{16}$ in., which would give a calculated tensile strength of 32,850 lbs. A specimen of the iron of this beam was then tested for tensile strength; the result was 17,140 lbs. per sq. in., or not much over 50 per cent. of that which was obtained by calculation based on transverse strength.

A remark is here necessary in explanation of preceding calculations. The Ordnance Manual, p. 436, gives the following expression (to be found in all works on the strength of materials) for the breaking weight of a rectangular beam supported at both ends and loaded in the middle:

$$W=4\,S\frac{b\,d^2}{l}$$

in which W is the required weight, l the distance between the supports, b and d the horizontal and vertical dimensions of the section. If the law of elasticity upon which the theory is based held good, that is if the "co-efficient of elasticity" remained constant for all degrees of extension and was identically the same *for compression*, the co-efficient S would be *one-sixth the tensile strength of the material.* As it is the outer and upper fibres only which are extended to rupture when the beam gives way, we should therefore have, calling T the tensile of those fibres, or of the material:

$$T=\frac{3}{2}\,W\frac{l}{bd^2}$$

More generally if W′ is any weight (*less* than the breaking weight W), supported at the middle, and R the tensile strain thus produced upon the outer fibres, we should have

$$R=\frac{3}{2}\,W'\frac{l}{b\,d^2}$$

It is thus that I have calculated the "tension of outer fibre" for different stages of the experiments—there being, in fact, no other way. I have already remarked upon the inaccuracy of this calculation when it is applied to great extensions or to strains approaching rupture. In fact, the assumptions of constancy in the coefficient of elasticity and of its identity for compression and extension, however convenient, are well known to be in opposition to the results of experiment. In Morin's Table (p. 8, "Resistance de Materiaux") the coefficient of extension for wrought-iron is, at the state approaching rupture, but about $\frac{1}{23}$ of what it is at the beginning.* On the other hand, the co-efficients for compression and extension are not identical. Hence, as the fibres along the section of rupture are in all stages of extension, from a maximum at the upper fibre down to zero at the neutral axis, and thence have increasing degrees of compression to the lower surface, such formula can give but inaccurate results. Nor can they approach to much accuracy when the co-efficient, S, as applied to breaking strains, is determined by experiments; for the results are extremely variable, depending on the character of the iron and the form of the section. In the three instances given in the Ordnance Manual for "cast-iron," S varies from $\frac{1}{3}$ to $\frac{2}{3}$ the given tensile strength of the material. In the single case given for "bar iron" it is but little over $\frac{1}{6}$ of the corresponding tensile strength.

In the case of the forged iron beams experimented upon, the resulting value of S would be, for the first a little less, for the second a little greater, than $\frac{1}{6}$ the strength which direct experiments proved to belong to the "unworked" iron of the beams.

In the case of castings, in the first case S would approximate to $\frac{1}{4}$, in the second to $\frac{1}{3}$ the real tensile strength of the iron. In all these cases the ratio of these fractions to $\frac{1}{6}$ is the ratio by which the *calculated* exceed the true tensile strengths, as afterwards determined by direct experiment. The calculated "extension of fibre" does not err, necessarily, in the same direction. It does not, probably, exceed the real extension, and must, indeed, fall short of it if the neutral axis, through inequality in compression and extension, is lower than the assumed central position, as it probably is in all cases in which S exceeds $\frac{1}{6}$ T.

The average "tenacity" of cast-iron gun-metal, prior to 1841, is given at................23,638 per square in.
In 1851, it was.....37,774 " " "

The mean tensile strength of the iron of the 10-in. guns which endured 2,540 rounds each, was 26,038 lbs.

Although the *cast-iron* of these beams proves comparatively weak, the extensibility of the metal appears to be much

* The extreme extension in this Table does not exceed or even equal that which was found for the outer fibres of the first beam broken—viz., .0463.

greater than that of the gun-metal tested by General Rodman (p. 159, Experiments on Metals, etc.).

The fracture of the iron in the beam at first cast exhibited a leaden gray color and a crystalline structure quite uniform, but quite as coarse and *apparently* less close than that of Lake Superior charcoal pig-iron; the fracture of the re-cast beam showed greater compactness. The particular composition of iron used in these beams appears to be quite inferior as cast-iron to what it is when wrought.

Limited in scope as are these experiments, I think they furnish presumptive evidence of the superiority of forged wrought-iron, in large masses, over cast-iron, for ordinary transversal strains and for the endurance of shocks. The universal use of wrought-iron for shafts of steamships, etc., is in accordance with this conclusion; and if such observations as we could make at the firings furnish no proof that the elastic forces of the iron were fully called into play, yet the subsequent experiments go to show that neither the process of forging nor the crystalline structure which results from it is *necessarily* destructive of ductility and tenacity. If it appears, indeed, that even the most ductile and tenacious wrought-iron is, like cast-iron, *brittle* under the action of instantaneous applied rupturing strains, yet the presumption of superiority is certainly in favor of that material which possesses the above qualities in the highest degree.

The press, used under the direction of the able Naval Constructor, Mr. B. F. Delano, was one made in England, and set up in the Brooklyn Navy Yard, for the purpose of bending armor plates. Its gauge was graduated to 2,000 tons (of 2,000 lbs.), and the accuracy of its indications was thoroughly tested.

In relation to forged iron in masses of large dimensions (such as shafts of steamships, rolling mills, etc.), there is great diversity of opinion, and little experimental knowledge. That they frequently break is notorious. If it happens that a flaw in the forging is found, as is sometimes the case, the rupture is of course satisfactorily *explained*, even if it casts doubt upon the reliability of the forging process. But quite frequently no flaw is found (and the means and processes are so thoroughly perfected at the present day that there is no excuse for their occurring), while the sharply defined and highly crystalline fracture, which is invariably observed, is usually considered an indication of dangerous brittleness. The various explanations already mentioned as having been applied to the fracture, by gun-shot, of the beams in the target, are freely offered. Inconsistent with each other, experimental observation is almost wholly wanting to test their validity. Hence the experiments herein recorded, limited as they are, may prove of some value.

THE EFFECT OF TEMPERATURE ON COAL GAS.

From "Engineering."

Of the many experiments which have from time to time been made on the illuminating power of coal gas under different conditions, very few, we believe, have been conducted with a view of ascertaining the extent to which that power is affected by the temperature to which the gas is exposed, and for this reason some experiments of this kind, which were not long ago carried out in the laboratory of the University of Munich, possess a special interest. In these experiments the illuminating power of the gas at the normal temperature of 64½ deg. Fahr. was taken as the standard, and the object was to compare, by means of a Bunsen's photometer, this illuminating power with that obtainable when the gas was burnt in the same burner at a higher or lower temperature. In order that this might be done, the burner was attached to a U-tube, which could be immersed either in a cooling mixture or in a liquid at an elevated temperature. The illuminating power at the normal temperature being represented by 100, it was found that when the U-tube was immersed in snow, so as to bring the temperature of the gas down to 32°, the illuminating power was reduced to from 76 to 85; while when a mixture of salt and snow was used to give a temperature of—4 deg. the illuminating power

of the gas was reduced to from 33 to 40, or, in other words, it was only equal to about ⅓ of that which it possessed at the normal temperature. Of course such a temperature as —4 deg. is one to which gas is never practically exposed, at all events, in this country; but the fact that even at a temperature of 32 deg. there was found to be an average diminution of the illuminating power to the extent of about 20 per cent. is an important one, well deserving of attention.

Heating the gas above its normal temperature was found to have far less influence upon its illuminating power than cooling it below that temperature, and this was a result which might have been expected, for reasons which we shall point out presently. By immersing the U-tube in boiling water, and thus raising the temperature of the gas to 212 deg., it was found that the illuminating power was increased to 104 (the illuminating power at the normal temperature being, as before, represented by 100), while when melted paraffine was substituted for the water, and the temperature thus increased to 288 deg., the illuminating power became 118. Thus while a reduction of temperature of about 32 deg. lessened the illuminating power by about 20 per cent., an increase of temperature of 224 deg. raised that power by about 18 per cent. only. This state of affairs is readily explicable if we suppose the reduction of temperature in the former case to have been sufficient to cause the liquefaction of a portion of the hydrocarbons associated with the gas, as in that case the total amount of sensible and latent heat abstracted from the gas by the reduction of temperature of 32 deg. might even be greater than that imparted to it when its temperature was raised to 288 deg. In all the experiments the air for supporting combustion was, we believe, supplied at the normal temperature; but it would have been interesting if, in the case where the gas was cooled to 32 deg. Fahr., the light had been supplied with air at that temperature also, and notice taken of the effect.

In the course of the experiments it was found that, after the gas had for some time traversed the tube immersed in the cooling mixture, a thick coating of ice was deposited on the interior of the tube. The water resulting from the melting of this ice had a strong smell, was neutral to test papers, but when exposed to suitable tests gave a feeble reaction, showing the presence of cyanogen. With indigo carmine (sulphindigotate of potass) and sulphuric acid, it developed the blue color of indigo, and evolved the odor of nitrobenzine. To determine the amount of water carried by the gas a large quantity of the latter was caused to pass very slowly through a drying tube charged with pieces of pumice-stone soaked in sulphuric acid. A large number of experiments made in this way on the ordinary gas supplied to Munich showed the quantity to average about 1.6 grains per cubic foot.

COKE IRON AND CHARCOAL IRON.

By M. BERTHAULT.

Translated from "Les Mondes."

What is the cause of the inferiority of coke iron to charcoal iron? And why is the charcoal iron of certain countries of Europe inferior to that of Sweden and Russia?

From my investigation of the composition of cokes and the coals which produce them, and of the woods of different kinds employed in Sweden and other countries of Europe, I have come to the conclusion that this inferiority proceeds mainly from the insufficiency of the salts of potassium and sodium which are employed in the fusion of the iron.

The following is from the extensive work of MM. Flachat, Barrault, and Petiet.

No. 137. POTASSIUM, SODIUM, CALCIUM.

These metals produce a decarbonizing effect upon the ore without combining with it; the potassium contained in the cinders of the combustibles does not appear in the slag or in the metal, but is volatilized so that it is found in great quantity upon the walls of blast furnaces.

Lime dissolves the silica contained in

ore, and, besides, sets free a large quantity of sulphur.

Bessemer and Heaton in their processes both base their system of reduction of ores upon the oxidizing reaction either of nitrate of soda or of nitrate of potassa.

The quantities of alkaline salts contained in various fuels are given by MM. Violette and Archambault, as follows:

ANALYSIS OF OAK ASHES.

Carbonic Acid	28.2	
Sulphuric "	7.6	
Muriatic "	1.8	
Silica "	1.7	
Potassium	33	60.7
Sodium	27.7	
		100

White Oak Ashes	0.075	of Alkaline Salts.
Chestnut "	0.146	" "
Parisian Oak "	0.150	" "
Pontgibaud "	0.200	" "
Allevard Fir "	0.257	" "
Norway Fir "	0.500	" "

St. Etienne Coal, Ammoniacal Carbonate.
Auzin Coal, ... Ashes, Water, & Potassium, 0.128.
Chaulevay Coke, No Potassium.
English ", St. Etienne ", Rive-de-Gier " — No Potassium, but Salts of Lime, (Sulphuret and Carbonate).

It seems, then, to be demonstrated that the salts of potassium and sodium introduced into the blast furnace with the ore and the fuel, give, with coke or with other fuel, iron of superior quality. Everything depends on the quantity of potassium or sodium. The salt should be the carbonate of potassium, such as is obtained from vegetables, and known as raw potash, pearl ash, Russian or American potash, etc.

In order to obtain a uniform quality of iron in the same blast furnace or manufactory, in other words, to apply the proper quantities of the salts, they must be dissolved in some agglutinating mixture, and the ore, or rather the porous coke, must be covered with the compound; diluted clay or blood mixed with water will answer.

The question of expense is of course to be considered, but the expense will be compensated by the improved quality. Potash is still very dear; but it is probable that the water of salt marshes mixed with lime could be used. The high temperature would decompose this mixture and produce the necessary decarburant gas. By this means the greater part of the work now done in the puddling furnace or the Bessemer apparatus might be done in the blast furnace.

INFLUENCE OF RAIN ON FILTRATION OF RIVER WATER.

From "The Mechanics' Magazine."

Whether it is that we have so much and so general rain in England as to have, strictly speaking, no rainy season, or that the geological formation of our soil is essentially different, yet it is certain that we do not experience the same effects that attend the rivers of other countries at certain periods of the year. During the autumn and winter months our streams, especially those in mountainous districts, do become swollen and turbid to a very considerable degree, but still do not approach the condition of those in higher latitudes. As an example of a river which is affected perhaps to a maximum by the rainy season, we may select the Hooghly, or, as it may be appropriately termed, the river of Calcutta. A most valuable and interesting report on this subject has been published by W. Smith, Esq., C. E., Chief Engineer to the Calcutta Water Works. As it bears directly upon the welfare and interests of both the native and British population residing on the banks of the river, we shall proceed to discuss its contents with all the more alacrity since the condition of our own rivers and streams is a disgrace to a civilized nation. Our readers were made well acquainted with this fact in a recent article on the pollution of rivers, which was based on the indisputable assertions and statements contained in the lately issued report of the Royal Commission appointed to investigate and inquire into the whole bearings of the question. In whatever land a river may be situated, and under whatever circumstances it may be placed, the effect of heavy and sudden rains will be to cause flooding, and to surcharge the water with more or less solid matter. The nature of this solid addition materially influences the future state of the water, and the accomplishment of its

proper filtration. It is of course taken for granted that all water intended for the supply of cities and towns, from whatever source it may be derived, is passed through filtering beds before being permitted to flow into the delivery pipes. If, therefore, by reason of floods, the river or other source of supply become strongly impregnated with any substance which would tend to choke up or clog the filtering beds, it is manifest that the flow of the water would be very much impeded, the filter beds rapidly deteriorated, and the whole operation rendered increasingly troublesome and expensive. Such is thecase with the Hooghly. During the monsoon the river becomes charged with a very fine description of clay, which seriously increases the difficulty of filtration. In some experiments made upon small samples of the turbid water with an ordinary paper filter, it was found that even after settling for a considerable time, it either passed through in a partially muddy condition, or that a layer of clay formed on the filter, which would not allow any water to pass through at all.

The general condition of the Hooghly at the various periods of the year differs considerably. From November until March it is not sensibly contaminated with mud, and that which it does contain speedily subsides, leaving the water nearly clear. During the next four months it receives large additions of foreign substances and a great deal of mud; but the particles are coarse, and subside without much difficulty, so that the filtration is not impeded. From the end of June to the beginning of November is the trying time for the filtering beds, although it is not the quantity but the quality of the mud that is the objectionable feature in it. The fine clay that remains suspended in the water will not settle; it will pass through a coarse filter, but forms, as has been already stated, an impervious layer or coating over the surface of a fine one. The object of the experiments to which we shall refer was to determine the best method of managing the filtering operations, and the most suitable materials to employ for the purpose. With this view, four filtering boxes were constructed of teak, and lined with sheet-zinc. Two of them were 6 ft. by 6 ft. by 6 ft., and two were 3 ft. by 2 ft. by 6 ft. deep. The other arrangements were common to all. They consisted of a small iron box fitted below the centre of the bottom, with an iron pipe passing below the bottom of the box to one side, and then passing upwards along that side. In addition, each box was supplied with a stopcock and various exit pipes at different heights, by which the flow of water could be regulated by the degree of pressure required. Four iron tanks, containing each 400 gallons, were placed at a higher level to act as settling reservoirs. These were furnished with siphons and stopcocks for drawing off the water to the filters after settlement had taken place. The filtering materials consisted of silicious pebbles, and gravel of different sizes, and of sand, some of which was coarse and some fine. The latter was obtained near Pultah, the former in the vicinity of Mugra, and one of the objects of the experiments was to determine their relative values as filters. It is not enough for a filtering bed to deliver the water in a state of purity, but it must also deliver it in a sufficient quantity for the supply demanded. A bed of Pultah sand 30 in. in thickness was proved to be able in a very short time to deliver the water free from mud, while a similar bed of Mugra sand 48 in. in thickness did not arrive at that stage until after the lapse nearly of a couple of months, during which time it yielded only about half the proper quantity of water. By exceptional management the coarser-grained sand can be made to deliver the muddy water clear, but the most careful management will not raise it to the standard of the other and finer description. It becomes seriously impaired in efficiency by an increase in the pressure of the water, and also by the pressure of the fine kind of clay which results from the flooding of the river.

Among the items constantly occurring in the working expenses of water-works, is the cleaning of the filtering beds, and this mainly depends upon two circumstances. One is the quality of the water supplied, and the other, the nature of the material used as a filter. If the bed become choked up so that the flow be intercepted, it must be attributed either to the foul condition of the water, or to the badness of the material, or perhaps to both. A remarkable distinction must be here noticed between the manner in which filtration proceeds when the water is very much impregnated with foreign particles, and

when it is comparatively pure. Under ordinary contingencies, the filtration and separation of foreign particles is effected by the first three or four inches of the bed, and the remainder of its depth remains nearly free from impurities. In a word, the filtration is accomplished by superficial aid alone, and does not penetrate much below the surface of the filter. This condition of affairs no longer prevails when the rainy season sets in. At any rate, it is not the case with the waters of the Hooghly. The fine clay suspended in it is not arrested by the uppermost layer of the filtering bed, but finds its way down to the bottom. In the experiments in question, different depths of sand were operated upon with the same result, although it was proved that the depth to which the clay penetrated depended upon several circumstances, such as the pressure, the consistency of the sand, and the rate of the flow. The proportion of the clay diminishes with the depth of penetration, as might be expected. There are two methods in ordinary use for cleaning the sand of filtering beds when it is needed. One is to wash the layer of sand with water, and the other, to remove it altogether and replace it by a clean stratum. Neither of these plans is recommended for filtering the Hooghly water, but it is proposed not to remove the dirty layer of sand until the whole bed requires a renewal. It is very justly argued that if the plan of removing the first three or four inches in thickness be adopted, there will always be in this case a clean layer on the top of one which is not clean, but which is to a certain extent impregnated with the peculiar fine clay described. The method recommended is to commence with a good thick bed which will last during the rainy season, and which will not require a thorough renewal until the process of filtration has returned to its normal condition, and the operation may be easily accomplished. No analogy can be fairly drawn with respect to the whole management of filtering beds in India from the manner in which they are treated at home. The conditions of the two cases are entirely different, and consequently different means must be resorted to in order to successfully carry out the various operations demanded.

TELEGRAPHS IN THE EAST.

From "Engineering."

The "Bombay Gazette" expresses its opinion that the world has gone mad on the subject of submarine telegraph cables, but supports its demand for one between Bombay and Galle, which is assumed will cost a mere bagatelle of £200,000,* and be more speedy and more certain than a land line.

Truly telegraph cables are in high favor just now, and the public, ignorant of or rejecting the lessons taught by numerous failures, and without first ascertaining if the same conditions apply, on the strength of the success of the Atlantic cables, are perhaps somewhat careless of the consequences of investing in any great scheme of submarine telegraphy.

There can be no doubt that there are still some good openings left for submarine telegraphs which offer fair prospects of being remunerative; but if the conditions under which submarine telegraphs pay, and pay better than land lines, be absent, success is impossible. We call attention at length to these matters because of their intense effect on the commerce of this country. Any scheme that is accepted by the public and fails, throws back telegraphic extension for years; witness the failure of the first Red Sea and the first Atlantic Cable. It will be too late when the day of repentance cometh—as come it must for the public, or the shareholders, or possibly both—to inquire why legislation did not intervene to insist on the adoption only of those routes which alone can offer reasonable prospects of providing good communication at the lowest possible price.

During the last year we have placed upon the market six or more schemes for extending telegraphic communication to China, Japan, and Australia. Some of these are on the direct line of communication, and all possess some good elements,

* It cannot be laid for less than £350,000, or possibly £450-000.

but not one of them is perfect or even approximates to perfection, excepting the submarine schemes chiefly promoted by the Telegraph Construction and Maintenance Company, who have adopted such a circuitous route that even if they earn a dividend they must expect to be cut out by any line or combination of lines which is sure to come forward to seize the shorter and what happens to be the stronger route.

The staple argument of the cable companies is, that cables work cheaper, better, and with greater speed than land lines; the correctness of this depends upon their relative length, and special condition of climate and place. On the Indian Government lines, messages are transmitted between the Presidency towns and Kurrachee with very great rapidity; they are, in fact, transmitted on well-insulated lines, without any repetition whatever over distances of nearly 1,800 miles.

Land lines cost less than one-third the price of cables, are easily repaired, permit of several wires, a much lighter speed of signalling, and generally offer alternative routes; such lines, repaired at intervals, last for ever, but as yet we know, but little of the longevity of cables, even when laid in very deep water. Our knowledge is almost limited to the cases published in the Blue Book of 1860 ("Construction of Submarine Cables"), according to which a very large proportion of the cables laid in shallow waters are destroyed either by abrasion against rocks or gravel, or by ships' anchors, in less than ten years. We also know that both the Atlantic cables have been more than once ruptured, and have remained so for months at a time. Our experience of the longevity of cables laid in the tropics and Eastern seas is almost limited to the first Red Sea cable, the Persian Gulf cable (one of the best cables ever constructed), the Cuba, and some short cables laid in India. From this experience we learn that in hot climates, and especially in shallow water, the wire guards of cables suffer severely from the heat, from abrasion against coral and other rocks, ships' anchors, and that the core is attacked by Teredo worm when exposed.

Cables laid in very deep water are pretty safe from ordinary accidents, but they must have shore ends, and when damaged cannot be repaired at any time without considerable expenditure of time and money, and not at all in bad weather, which, in tropical seas, means during the five or six months of the rainy season.

The popular belief that signals are always transmitted with greater speed through cables than land lines, is due to ignorance of the conditions under which this becomes possible. It can only happen when the length to be signalled through is so great as to require more repetitions on the land line than by cable.

On a land line the electric current discharges itself instantaneously, therefore the limit to speed is the rate with which the signalling instruments can be manipulated; under certain arrangements it is quite possible to attain a speed of 60 words per minute, but in practice the rate rarely exceeds 25 to 35 words a minute. On a cable the case is quite different; the conductors being enclosed in a dielectric, in contact with the earth or water, the cable cannot discharge itself instantly. In fact, electric phenomena occur which prevent the rapid transmission of signals, and more than 10 or 12 words per minute cannot be transmitted with any pretension to accuracy.

The limit over which telegrams are transmitted automatically in fair weather, is about 800 miles in Europe, about 1,000 miles in America, and somewhat more in India. During the continuance of great atmospheric disturbance—such as the commencement and breaking up of the rainy season—it is difficult to transmit signals without repetition, even 500 miles.

No limit has yet been found to the length of cable through which it is possible to transmit a signal; but as the signalling decreases in speed as the length of cable increases, about 1,200 miles is considered the most convenient distance for stations to be apart. At this distance 12 words per minute is a fair rate of signalling on a cable of large capacity.

It is therefore obvious that, *cæteris paribus*, a cable is inferior to a land line for distances of less than 2,000 miles. We have already stated that cables are at a disadvantage in shoal waters. Land lines on a sea coast, especially in the tropics, are, on the other hand, also at great disadvantage; the hot moist air carries off a great deal of the current and rapidly corrodes the wires. They are also peculiarly

liable to interruption from cyclones and severe winter weather. Lines through dense forests, especially in the tropics, are difficult to maintain. Lines that cross broad rivers are at great disadvantage. As a cable costs at least three times as much as a land line, it is worked to best advantage when it shortens distance—such as when it is laid across a deep bay or a strait, or an arm of the sea.

A well-erected and well-insulated land line through an open country, along a good line of communication, especially if that line be a railway, is as near perfection as can be, and where these conditions rule, a land line is incomparably preferable to the very best cable that can be laid.

The Red Sea cable will be laid from Suez to Bombay in very deep water, by a route far shorter than would be possible for a land line, and should, if secured against abrasion on the coral rocks near Mocha, be a success; but a cable laid between Bombay and Galle must follow the general run of the coast, and be actually longer than the land line. It will be in shoal water, amongst rocks, and for many months in each year will be exposed on a lee-shore to the full force of the south-west monsoon; the landing, too, at Galle, will be exceedingly difficult. A cable, laid from Galle to Singapore will also meet with great difficulties; it cannot be laid direct to Acheen Head, and all through the Straits of Malacca, 400 miles, it will be exposed to all the dangers inseparable from shoal water of only 20 or 30 fathoms. Ships beating through the Straits, anchor anywhere most convenient to themselves, a certain source of injury to cables laid in these waters.

What the public really requires is, not a cable between Bombay and Galle, but the adoption of that scheme which combines in one homogeneous whole all the strong points of each of these projects. What they should demand is, that line or combination of lines which will give them the best results at the lowest possible cost. Now a glance at a good map of Asia shows that there is no necessity to go to Galle* at all; the most direct mode of reaching Singapore from Bombay is through Madras; and if it be remembered that Bombay and Madras, which will very shortly be united by railway, are only 760 miles apart—that is to say, within easy direct electric communication—it is evident that a telegraph starting from Madras, starts with a great initial advantage.

The facilities for laying a cable from Madras are also far better than those presented by Galle. At Galle, the harbor is confined, the entrance narrow, and the surf even in the calmest weather breaks incessantly over its rocky coast, and nowhere round the coast, until the neighborhood of Trincomalle is reached, exist bays or indentations suitable for the landing of a cable.

From Madras, on the contrary, a cable would be laid on a sandy bottom, and start in the direction of the point to be reached, and if the site for landing be judiciously chosen, such as where a bar is forming across a small river mouth, the cable would soon bury itself and become practically indestructible.

The scheme that we should like to see projected and well supported by one large company is that recommended by Colonel Robinson, the Director-General of Indian Telegraphs, viz., lay a cable from Madras to the mouth of the Pak-Chan river, the southern extremity of the Tenaserim Provinces, touching at Port Blair, whence a branch should be laid to Rangoon, and possibly to Acheen Head; a short land line of 70 miles across the isthmus at Kra would connect this cable with another to be laid across the Gulf of Siam to Cambodia Point of Saigon. From Tayoung, the east terminus of this short land line, a branch land line should be carried up the eastern coast of Siam to Bangkok, only 270 miles distant. Singapore should be connected either by a land line along the east coast from Tayoung, or with Cambodia Point by cable.

This scheme presents, apparently, the strongest, cheapest, and most direct main line which can be laid between London and Hong Kong, with branches to Galle, Rangoon, Bangkok, and Singapore, the latter capable of extension to Australia. It is evident that this line, besides being stronger, would cost so much less, that it could afford to transmit telegrams at much lower cost, and with greater speed, than the Galle-Singapore cable; and hence, whether the Govern-

* Galle seems to have been selected because it is the southernmost point of India, and the grand junction station for the several lines of steamers plying on the Eastern seas, and this, though ample reason for making it a branch, is not sufficient for putting it on the main line of communication.

ment of India carries out its proposition to give substantial aid (in the way of a cable across the Bay of Bengal) to any scheme that shall give evidence of stability, or not, we trust ere long to see a company, or combination of companies, started with the object of undertaking either the extensions beyond Port Blair or the Pak-Chan river, or of the whole scheme in its entirety.

WIND PRESSURE ON BRIDGES AND ROOFS.

From "The Engineer."

Recognizing, as we have always done, and advocating as we always do, the advantages of a sound knowledge of theory, and an accurate appreciation of its value, it must, nevertheless, be admitted that there are certain instances in which it becomes absolutely impossible to reduce its dictates to practice. It is not merely the labor that it imposes on its votaries in some particular cases that acts as a deterrent, but also the uncertainty as to the result that is ultimately arrived at through its instrumentality. There are some theoretical calculations which, with all the respect we have for their intrinsic merit, do unfortunately terminate in "vanity and vexation of spirit." In such examples practice and experience come most opportunely to the rescue, and solve the problem that by reason of its complexity would otherwise remain, to all intents and purposes, indeterminate and unproven. Digressing for the moment, the pertinent question presents itself, how is it that some engineers, by an almost natural aptitude—it might almost be termed instinct—do perceive at a mere glance the fitness of any proposed design for its required duty? They make no elaborate calculations respecting the dimensions of the several parts, they do not care to inquire whether this member is a strut and that a tie, whether there are 5 tons or 6 tons per sq. in. upon the metal, but state at once, without the slightest hesitation, that it will carry such and such a load safely. Whence is this practical discernment derived? In our opinion it is due to natural ability and genius.

In the designing of bridges and the proportioning of their several parts, the conditions attending the development of the strains are usually determined upon the separate assumptions of a fixed and a variable, or, as it is also termed, a dead and a live load. Two tables of the results should always be compiled—the one giving the maximum strains under the hypothesis of the load being uniform and stationary, and the other, those arising from the action of the moving load in the several positions it can practically occupy. Should the latter calculation be omitted, as it sometimes is, it is impossible to arrive at the opposite duties which may be required of any particular member of the structure, and any attempt at scientific and economical counterbracing becomes impossible. The experience derived from the construction and erection of the Britannia Bridge tends to demonstrate that the pressure of the wind, so far as structures of that class are concerned, produces little or no effect upon their general equilibrium. Not that it is to be disregarded; but it cannot be considered as materially increasing the assumed load, either fixed or variable, which enters into the calculation of the necessary sectional area of metal proper under the circumstances. The resistance to wind pressure is obtained not so much by strengthening, but by stiffening a bridge or roof. Insistent weight and rigidity are the best counteracting elements. The type selected for a bridge considerably modifies the nature and intensity of the force of the wind. A girder with an open or lattice web will be but little affected by the most violent storm, at whatever elevation it may be placed; but if a solid-sided or plate girder be in the same situation there will be a large amount of lateral stress induced upon one or other, and perhaps upon both of its sides simultaneously. Taking one of the Menai tubes, for instance; if we imagine a strong wind blowing upon one of its sides, it may be regarded theoretically as equivalent to a temporary weight or pressure acting uniformly, or what amounts to the same, uniformly distributed over its whole length. Under these conditions, it is obvious that there is a close analogy between the resulting strain

and that induced upon the centre of a girder by a horizontal load. The maximum bending moment will be evidently proportional to the pressure of the wind upon the unit of surface multiplied by the square of the span, the resistance being directly as the *vis inertiæ* of the bridge and its own rigidity. The maximum pressure upon the Britannia bridge was found to be only half a ton per sq. in. This is also apparent from the fact that although the wind may not affect a bridge throughout all its parts with the same degree of force, yet its action is never so purely local as to be confined to one particular section or short length. The tendency of a wind pressure on the side of the Britannia tube is not to shear the web in any particular vertical plane, but to sweep the whole structure bodily into the straits. In this instance any more stiffening applied solely to the side would be of little or no use. It is the whole bridge that must be rendered rigid. The two tubes are assailed *en masse;* their only safety is in a close and intimate union, combining their individual resistances so as to act as one rigid piece of construction. It was not at first intended to place the two tubes in this relation with one another, but the advantage of so doing was speedily recognized and acted upon.

A roof is differently affected by the wind to a bridge. In this respect it must be confessed the modern light iron trusses are comparatively at a disadvantage with the older, heavier type of timber constructions, which, although the absolute covering of slates, tiles, or of whatever nature it might be, was sometimes blown off, yet remained firm and unshaken. The pressure of the wind may affect a roof in three ways. It may affect it from without or from above, from within or underneath, and it may also affect it locally, or confine its action to one-half or even one-quarter of the entire principal. Let us take as an example a curved trussed roof of the type that is particularly applicable to stations, engineering workshops, and manufacturing sheds, and proceed to determine in what manner allowance is to be made for the pressure of the wind, which has been observed in this country to obtain a maximum value of 55 lbs. to the square foot. First for the external action. The roof being curved, it is clear that even on the supposition that the angle of incidence of the wind is constant, the angle of actual pressure will vary from the crown to the springing. But in reality the wind rarely blows in a storm at a constant angle. On the contrary, it blows at all angles from the vertical to the horizontal, and, in consequence, will be sometimes vertical, sometimes normal, and sometimes tangential to the surface of the roof. The assumption that the pressure of the wind may be considered as a vertical force, and that therefore so many pounds per sq. ft. may be added to the weights already estimated to rest upon the structure, is erroneous, for in that case it would affect each half of the roof equally and simultaneously. Under these circumstances, therefore, it would be equivalent to simply increasing the uniform load, and regarding the principal as subjected only to a load of that character, which is incorrect. It is true that a roof is not acted upon by a movable load in the same manner in which a bridge is affected; but it is subject to a variable load, which, as it has been already stated, may cover the half or the quarter of one side. At whatever angle the wind might be assumed to act, it is scarcely possible that its influence could be spread over a less space than one-quarter of the half, or one side of the roof. Sir W. Fairbairn observes that, in reference to roofs, "every pair of principals composing such structures should be self-supporting, that is, should have sufficient stiffness within itself to sustain a load of 40 lbs. per sq. ft." This load is considered to be a uniform load. How, then, is the variable pressure of the wind to be taken into account? In the first place, it must be borne in mind that 40 lbs. per sq. ft. is considerably in excess of the actual weight of the covering and the roof itself, and includes a certain allowance for wind pressure. The largest slates weigh bnt a trifle over 8½ lbs. per sq. ft., so that the margin that is left can be well imagined, more especially as in the examples to which allusion is made a much lighter covering than slates is usually adopted. In addition, there is also the additional guarantee of security afforded by the ratio of the working or safe load to the ultimate strength of the material. Instead, therefore, of treating this weight of 40 lbs. per sq. ft., or whatever other unit, not less than this, that may be adopted, as a uniform load, it

it should be treated as both a uniform and a variable load. In other words, the effect of each successive portion of this or a greater weight situated at each apex should be carefully ascertained by a diagram of strains, and the results tabulated. The one will give the strains due to a uniform load, and the other that due to a partial one. The latter will indicate the local action of any particular weight or weights, and will point out how, under certain conditions, particular parts of the truss which are under either compression or tension, when subjected to a uniform load, will undergo strains of an opposite character when that load is regarded as only partially distributed. Having, therefore, ascertained the conditions of strains due to a uniform load upon the various parts of the roof, and tabulated the results, let another table be compiled showing the effects of a partial loading, and then the necessary counterbracing can be introduced. But there yet remains a very important element of stiffness to be added, namely, the wind ties. These are required, not only to assist in resisting the external violence of a storm or hurricane, but also to prevent the pressure from underneath literally "blowing up" the roof. If the wind once gets "well under" a roof nothing but the fact that the greatest care and precaution have been bestowed upon its bracing will prevent it being carried away. We have known an instance in which, from want of attention to the proper tying together of the principals, the whole roof was lifted bodily off the side walls and landed in an adjoining field. The storm continuing, the walls gave way also, and the cost of restoring matters to their original condition amounted to £1,500. The fault of most wind ties is that they are not carried down low enough. There is no necessity for tying the principals together by wind ties. They are already amply secured by the purlins and the whole covering in general. The point to be aimed at is to tie them back upon the respective supports, so that the principals could not be lifted without taking the foundations with them. Basing our estimate upon the data already assumed for the maximum pressure of the wind, the upward force would be equal to 55 lbs. per sq. ft., and would consequently lift nearly that weight vertically. Unless, therefore, the insistent weight of the roof per sq. ft. were greater than this amount, it would at any rate be able to be seriously shaken by a force of that intensity. The aid, therefore, of some further mode of securing the principals is evident, as roofs of moderate, and even large spans, do not equal in weight the figures arrived at by observation for the maximum wind pressure. The strength required to be given to a roof will be most accurately calculated by a due attention to those principles which theory dictates, and practice sanctions; but its rigidity and stiffness will be best provided for by experience, combined with a little of that "artifice" which every thoroughly qualified engineer knows when and how to employ.

The *Athenæum* records the following important experiment made by Sir Thomas Maclear: "I built (he says) two pillars of solid masonry, and sheltered them at a locality on the line. Each carried a micrometer microscope. With these I compared the relation between the expansion of the standard iron bar and the indications of the two thermometers with oblong bulbs sunk in holes in the bar and surrounded with oil, and observed in the accidental temperature of the atmosphere, at short intervals, throughout 24 hours, night and day. The expansion of the bar in ascending temperatures, and contraction in descending temperatures, were about 2 hours behind the indications of the thermometer. To this circumstance are owing in part the rough results of comparisons in the field between the standard iron bar and the compensation-bars.

R. von Brause states that he has discovered coal of very good quality in the Santa Cartharina, near Ararangua. The seam which crops out has been explored for a distance of some 30 miles, and found to be an average thickness of 1 metre. This coal has been thoroughly tested and analyzed by Dr. Netto, of Rio de Janeiro, and is interesting as one of the very few instances of a true coal occurring in a recent geological formation, although in the United States and in Hanover (on the very borders of the Netherlands) two or three such occurrences are on record. The coal here alluded to is an excellent quality of gas coal.

REPORT ON BOILER EXPLOSIONS.*

From "The American Railway Times.'

Questions.

1. Please give me as minutely as possible, all the particulars connected with any boiler explosion with which you may be familiar, whether on your road or any other? The shape of boiler, thickness of iron or steel, diameter, and state as near as you can learn, what pressure of steam was carried at the time, and what was the highest pressure the boiler was ever subject to? Also whether there appeared to have been any defect in material or construction of the boiler; whether it had been weakened by corrosion, either inside or out; or was at any point "furrowed;" whether weakened by the gradual breaking of stay-bolts and bars? If so, how many were broken previous to the explosion; and in your opinion, what part of the boiler first gave way, and what was the cause of the explosion?

2. In your opinion, is the accumulation of mud or scale liable to produce an explosion, by the sheets becoming overheated and weakened from that cause?

3. Is the admission of feed-water at or near the fire-box, or where the water will come in immediate contact with the hot sheets, thereby producing a sudden, frequent, and unequal contraction, liable to weaken the boiler at such points?

4. Does the frequent variation of the pressure, and the frequent expanding and contracting of the sheets, produce crystallization, and, in your opinion, weaken the boiler?

5. In your opinion, have the minerals and impurities contained in water an injurious effect on the metal, thereby weakening it to such an extent as to be liable to explode?

6. In your opinion, as far as your observation goes, "What is the cause of boiler explosions?" Is it in all cases from an over-pressure that the boiler is not able to stand? From its being weakened by its long-continued use? Corrosion? Giving away of stay-bolts? Faulty construction? Bad proportion of boiler, etc.? Or do boilers sometimes explode, where no satisfactory explanation can be given as to the cause?

* Before the American Railway Master Mechanics' Association.

Report.

Gentlemen,—The subject of boiler explosions has attracted the attention of almost every one connected with the management of steam boilers and engines. Theories respecting their causes are innumerable, and multiply with every disaster of the kind. It would be impossible to state the various ideas advanced by mechanical engineers, practical men, and especially the unacquainted, who are unsparing in their advice. As a committee appointed to investigate this subject, we will endeavor to trace the causes to such defects as have presented themselves in past experience, and in conditions liable to occur in daily practice.

It is true, explosions have occurred where no definite causes have been given; but these are rare, and would, when thoroughly investigated, be reduced to a very small percentage of the whole number of disasters.

The theory of the decomposition of water seems to be a fallacy, as gases so generated would be harmless in this condition without the presence of air to combine with, and is generally discarded. The generation of nitro-glycerine or gunpowder, based on the fact that so many tons of water contain so many atoms of its chemical constituents, seems to have but little weight. Experimental philosophy, however, has demonstrated certain conditions which may occur. "The Projectile Theory," advocated by Colburn, Clark, Tindel, and many other eminent engineers and scientists, attracts attention. For instance, water, in its normal state, holds a large quantity of air in solution, which after boiling for a time, will be expelled, and liquid of a cohesive quality produced. In this condition the temperature can be raised high above the boiling point before ebullition takes place. On rupturing this cohesion, ebullition partakes the nature of explosion. It is conceivable that a great amount of heat may thus accumulate in a boiler, and lie dormant around the heating surface. The water in this condition prevents its rising to the surface, until some mechanical action, such as opening the throttle or disturbing the safety-valve, imparts motion to it, and steam of explo-

sive force is set free. Although a theory, experiments have demonstrated that such can be the condition of water at high temperature, and the liberation of such heat takes place with extraordinary violence.

Explosions which have occurred at the instant of starting the machinery, or producing commotion in a boiler after remaining quiet for a while, tends to substantiate this.

The following table shows an exceedingly rapid increase of pressure as the temperature rises :

Deg. Fahr.	Pressure in lbs.
234 =	7
248 =	15
263 =	22
275 =	30
302 =	45
320 =	75
338 =	105
356 =	135
374 =	180
392 =	225
410 =	285
428 =	345
450 =	430

When 15 lbs. pressure is obtained at 248 deg. Fahr., it takes about 2 deg. additional heat for every pound of additional pressure; when at 180 lbs., 374 deg. Every 2 deg. above this will give about 5 lbs. additional pressure, and at still higher temperature this effect is still doubled, and is thus ten times greater than at low temperatures, showing the danger of excessive heat in furnaces.

The theory of the "Spheroidal" condition of water has also attracted attention. This can be illustrated by pouring a small quantity of water on heated plates, having a temperature above that of high pressure steam. Such overheated plates repel the water thrown upon them, which assumes the spheroidal state, the excessive heat interposing a film of steam, until their temperatures are sufficiently reduced, when direct contact will take place and rapid evaporation follow. This can be daily observed in forges and rolling mills, where water is let upon surfaces of iron heated to redness, causing detonations like the firing of guns. Surfaces of considerable extent may be thus exposed in a boiler, and should the conditions be the same, a danger of explosion exists. The speedy unequal contraction of the boiler plates subjected to such a state, may produce fractures, or weaken them to such an extent as to cause serious apprehensions. This condition can take place in two ways: 1st, by the injection of cold water, which would rush on the plates absorbing the extra heat, causing a dangerous contraction of a whole sheet already in a weakened condition; 2d, by irregular firing and other means, large portions of scale liberated from the heating surfaces in a boiler, having an abundance of water and all appliances for indicating its state in perfect order. The scale adhering to the surface, and being a bad conductor of heat, we need not be surprised to find sheets literally destroyed by contintious heating and cooling. The use of the numerous anti-incrustation powders, or by mechanical impulse, may detach portions of it, exposing a large surface heated to redness to the action of the water, and cause explosions.

The Committee of the Franklin Institute found that clean iron plates vaporized drops of water fastest when heated to 344 deg. Fahr. The development of repulsive force was so rapid above this temperature, that drops which required a second of time to disappear at the temperature of maximum vaporization, required 152 seconds when heated to 395 deg. Fahr. One ounce of water which was introduced into an iron bowl three-sixteenths thick, at a temperature of 546 deg. Fahr., was vaporized in fifteen seconds, while at a temperature of 507 deg. Fahr., the most rapid evaporation was thirteen seconds. The cooling effect of metal is here exemplified by the increased rapidity of evaporation, which, at a reduced temperature of 38 deg., is effected in thirteen instead of fifteen seconds. This does not hold good in all cases, as an increased quantity of water, say from one-eighth of an ounce to two ounces, thrown on heated plates, raised its temperature of evaporation from 460 deg. to 600 deg. Fahr. Thus clearly showing that the time required for the generation of explosive steam under these circumstances is attended with danger, and it is doubtful whether the ordinary safety-valves may not be wholly inadequate for its escape.

Corrosion.

Corrosion, though we may retard its progress to some extent, will take place in and about the best protected boilers; rust being an oxide produced by the action

of moisture and atmospheric air on surfaces of iron exposed to it.

After testing a boiler to nearly double its requirements by hydrostatic or steam pressure, minute leaks will break out, through various causes; hard firing and rapid cooling will produce the same. The usual coverings of boilers prevent the immediate discovery of such damage, and not until the harm is done are means used to check it. Leaks, unless caused by defects in the body of sheets, are found along the laps of seams, through defective rivets, and around the braces and angle irons. Over-pressure and unequal expansion and contraction are the causes; the latter shows the most ruinous effects by "furrowing" the sheets along the laps, and fracturing them, when braces with insufficient bearings are attached. Corrosion takes place mostly on the under sides of boilers, and sheets are often found of less than $\frac{1}{16}$ in. thick required to stand 130 lbs. working, and eventually bursting with pressure. The legs of fire-boxes and bottoms of smoke arches are also liable to suffer from this cause, as the leaks from flues and seams and the presence of ashes produce a state so favorable. Internal corrosion progresses slowly; this may be accounted for by the comparative absence of air, and chemical combinations, which, to the present time, have not been sufficiently investigated. A singular phenomenon presents itself in this connection: recesses are found, varying in size from $\frac{1}{2}$ to $\frac{3}{4}$ in. in diameter, and extending nearly through the sheet, singly and sometimes in groups. They are generally found on the bottoms and lower sides of boiler shells, in places covered with sediment; though never sufficiently explained, it may be due to the concentration of saline deposits of certain kinds of water, which adhere to the iron and gradually cause corrosion.

Deposit of Sediment.

Scale and other solid matter accumulating on the heating surfaces of a boiler will prove detrimental in time. The furnace sheets subjected to the intense heat are unable to transmit it to the water wherever such deposits interfere. The structure of the iron is by repeated heatings soon destroyed. The first indication of such a state, is the bulging of sheets, causing cracks; and if occurring on large surfaces not properly stayed, a liability of suddenly giving away exists. The lower portion of fire-boxes are especially liable to this action, and sheets are often found bulged between stay bolts, and in many cases the threads partly stripped. No other explanation is given, as over-pressure would show its effects on all stay bolted surfaces alike. Deposit will accumulate rapidly in the front ends of locomotive boilers, causing flues to leak, and finally produce internal corrosion. Generally the first course back of smoke arch will be affected by this before any other part of the boiler, and explosions have occurred from the gradual wasting and consequently weakening of the sheets.

Explosions from Defective Steam Gauges and Safety Valves.

Safety valves of proper proportion, and in good working order, are considered sufficient for the escape of steam generated under ordinary circumstances. But there are certain conditions which may take place when steam is generated so rapidly, that they are useless even at ten times their usual area, and would not relieve the pressure in time to prevent explosions. In many instances the valves adhere to their seats, where they have not been used for a time, and in this condition are of no avail. We frequently hear of explosions where this is one of the given causes. Safety-valves will not prevent explosions where boilers are weakened by corrosion, old age, and inferior material. If properly constructed and taken care of, they may be considered a safety as regards over-pressure to a certain limit. The same may be said of steam gauges, which are a convenient and ornamental indicator, but are useless without care. At times the connection pipes become stopped by sediment, and it is not an uncommon occurrence to find them varying from 10 to 40 lbs. This may account for explosions which have taken place when the gauge was said to have shown a certain pressure, and yet was far above that actually indicated. Safety-valves and steam gauges are indispensable in all kinds of steam engineering, but, like many other attachments to locomotive boilers, are useless unless in perfect order.

Explosion from Deficiency of Water.

This is mentioned as a source of danger,

and may well apply to boilers where large shells or flues are thus exposed, as in stationary or marine boilers. In a locomotive boiler, the crown sheet would be the first affected, and immediately after this the tubes, which would readily give warning. A properly stayed crown sheet and fire-box are the strongest part of a boiler when kept in repair, and engineers are generally aware of the condition of water. At times they run short, but always prefer cooling down before burning a set of flues. The danger exists principally in the injection of water after the sheets become red hot, which may bring about the spheroidal state or cause fractures by contraction. Reliable pumps carefully attended to are the only safeguards. Water should be admitted in a part remote from the heating surface, so as not to cause contraction by the rapid absorption of heat.

Explosions from Defective Construction.

Faulty design and bad construction rank next as sources of danger. As a decided and varied opinion exists as to the proper and best shape of boilers, and different plans have apparently done equally well, we will only point out the one almost universally adopted. Over the crown sheet the shell is raised from 4 to 12 in. This part is usually connected to the shell by two sheets on top and part of sides, and fire-box by throat sheet. This and the top sheets have caused serious trouble on account of their shape and position, and are more than any other affected by the action of expansion and contraction. The usual absence of scale may be taken as an evidence, and the leaks along the seam, and often fractures of the surface of sheets, which gradually lengthen. Equally dangerous is the raised part on wagon top ; this part forming the half of an ellipse, has a tendency to assume the shape of a circle, and if insufficiently braced and stay bolted, can never retain its shape, so essential to its safety. Crown bars too weak for the resistance required of them are often met with, and in many cases very inferior material is used. By making the bars strong, and tying the dome and shell to them, thereby producing a counter strain, the danger from this cause is avoided, and the boiler must retain its original shape. Explosions have occurred from defective and improperly shaped crown bars. The usual manner of thimbling between the crown sheet and bars is a matter of importance. We frequently find thimbles from $2\frac{1}{2}$ to 3 in. in diameter and $\frac{5}{8}$ of an inch thick, bringing the bars too near the sheet, and is more liable to collect scale, which is difficult to remove by the ordinary means. Thimbles of the above dimensions form too great a body of iron, causing the sheet at the rivet to crack in various directions, weakening and destroying the material, which is liable to give away without warning. The proper size of stay bolts and the distance between them is a simple calculation, but the reckless mode of laying them out, that in many cases the inside and outside holes do not coincide in the line of their longitudinal strain by inches, is often met with. Stay bolts, especially the upper ones, are liable to give out where proper braces above the crown sheet are omitted. If one or two give out the rest will soon follow, by reason of an increased strain on the remainder ; and cases where 2, 3 and 4 rows have given out is no rare occurrence. The sounding of stay bolts in the usual way cannot always be relied upon, as broken ones will gather scale between the ends, and sounding can only be intrusted to the best of experts. Frequent explosions have occurred from the gradual breaking and suddenly giving away of stay bolts, and, being hidden from sight, some means should be devised by which they may be detected. As a remedy for this, we would suggest the adoption of hollow bolts, with holes drilled through them about $\frac{1}{4}$ of an inch or less in diameter. This would increase the cost to some extent, but the advantage would be, in case one should break either partially or totally, it would soon make itself known, by the discharge of steam and water through it giving due warning, and by replacing with another would relieve the balance from extra strain. Plugging the bolts on the inside when first put in would prevent (in case of a broken one) the discharge of steam in fire-box forcing it to the outside, which could be easily plugged, and prevent delays until replaced. This plan is adopted by many of the Continental railways, proving a success, and in many instances preventing explosions. The frequent variation of pressure together with the tensile strain upon such parts of

the boiler as are not perfectly sound and properly stayed, is one of the most powerful agents of destruction. The laps of seams have with few exceptions been held together parallel with the surfaces of the sheet. Although a universal practice, we will compare it with a second one coming into favor, and based on experiments made with the two kinds. It has been demonstrated, that a seam subjected to a severe strain assumes a shape in which the centre line of one sheet tends to strike the centre line of the other, forcing the edges out of their parallel position. Trials seem to prove the latter the rational shape, and enduring the greatest strain. This plan of shaping the sheets at the laps has a tendency to retain their natural position, and the difference in pressure would not cause them to change their shape and weaken them by the constant working at their connections.

We will briefly investigate the manner and manipulation of building boilers, the common abuses practised so generally: 1st. The loose manner in which the holes are laid out, and as a consequence the use of drifts, to make a bad job worse. Through the ignorance or neglect of workmen, the holes do not come right by sometimes half their diameter; are drifted until the sheet is fractured and the material destroyed. This habit cannot be too much reprehended, and the use of drifts, although considered indispensable by many good boiler makers, is productive of more mischief than good. 2d. The flanging of sheets has often destroyed the best material before the work was put together, especially turning flanges too short, causing cracks and flaws. Locomotive boilers working with 130 lbs. pressure are like magazines of powder, and we have enlarged on the details with a view of impressing its defects on the minds of all concerned. Too much care cannot be taken in their construction and management, and no man should be intrusted with it that shows a disposition to recklessness or neglect.

But in many cases, well-constructed boilers are injured by appliances of either convenience or luxury, which tend to shorten its life and increase the cost of repairs without giving any equivalent. Considering its purpose and the strength required, all unnecessary appendages should be avoided as detrimental to its existence. An opening, however small and well stopped, is an invitation for leaks. Good covering for the purpose of preventing radiation is necessary, but we call attention to the prevailing rage which hides dangerous defects and makes the vital part of a locomotive a camel's back for every conceivable contrivance. The following is the percentage of explosions assigned to different causes as received in answer to the foregoing questions:

To faulty design, bad construction, poor material, and carrying more pressure than boilers under such circumstances are able to bear	9
To broken stay bolts	3
To corrosion	3
Unaccounted for	2

The latter may be attributed to defective steam gauges and safety-valves, or by accepting the theories mentioned. The reported cases may be relied upon as being correct, and, although limited, must furnish a basis for conclusions until a greater number, or more detailed descriptions are obtained. It appears to be a positive fact that by far the greater number of explosions can be traced to rational causes, and speculations with its theories and unfailing preventives can only be exercised in exceptional cases. Locomotive building, though it has long ceased to be considered an art, requires the utmost attention in respect to general design, construction, and the selection of material. The locomotive from the date the first engine was placed on the track by the Father of Railways has a brighter record than any other branch of Mechanical Engineering. An extraordinary succession of improvements marks its course, and it is more to be regretted that explosions take place where supernatural causes are given, though it is universally admitted that steam is a controllable agent to all intents and purposes.

All of which is respectfully submitted.

J. Losey,
Wm. Hellar, } *Committee.*

A plan for uniform railroad gauge is under consideration by railroad men and members of Congress. Five-sixths of the roads already have the same gauge—4 ft. 8½ in. The expense of changing will not exceed $500 a mile.

GLYCERINE—ITS USES AND ABUSES.

By Prof. C. A. Joy.

From "The Journal of Applied Chemistry."

A few years ago glycerine was only known to scientific men ; but now it is so extensively employed as to be familiar to everybody. Scientifically, it appears to be a species of alcohol; popularly, it is the sweet principle of oil. For many years it was thrown away, but now it is saved and converted to numerous uses. Few chemical compounds have increased so rapidly in public estimation as this. From being regarded as a waste product, it has grown to be as valuable as its former proud associates, and appears destined to take a most prominent place in the arts. It exists in oils and fats, and as it was not essential in the process of making soap and candles, and no use could be invented for it, it was either destroyed or allowed to flow away. We are sorry to say that at the present time a great quantity flows down the throats of a long-suffering and much deceived wine-drinking public, instead of passing through the spout of the soap and candle maker. We do not propose to go into a long account of the way glycerine is manufactured, because any one curious upon that point can easily turn to an encyclopædia for information, but we know that it will interest our readers to learn something of the recent applications of this substance.

Housekeepers will be glad to know that if tubs and pails are saturated with glycerine, they will not shrink and dry up, the hoops will not fall off, and there will be no necessity of keeping these articles soaked. Butter tubs keep fresh and sweet, and can be used a second time. Leather treated with it also remains moist, and is not liable to crack and break.

For the extraction of perfume from rose leaves, from scented woods, from bark, from gums, there appears to be nothing better than glycerine, and this use of it is constantly on the increase, as the most delicate odors are perfectly preserved in it.

A soft soap, in which glycerine enters as a constituent, is highly prized in cold weather, when the hands become chapped, and can be used for washing in hard water.

For wounds and sores, and bites of venomous insects, glycerine is found to be a most valuable substance, as it either prevents the mortification of the parts, or it can be used to carry the remedies to counteract the effects of poison.

To preserve animal substances from decay, glycerine is now substituted for alcohol, in collections of Natural History, and it is employed to keep many articles of food from undergoing decomposition.

As it requires an intense cold to freeze it, even when mixed with its own bulk of water, it is largely employed to fill the wet gas metres.

Some kinds of candy, chocolate, confectionery, and fruit, which are preserved in tin foil, are kept moist by a small quantity of glycerine.

Delicate chronometers, clocks, and watches are lubricated with it. Copying-paper and wall-paper, for taking fancy colors, are also kept moist by a small amount of glycerine used in this manufacture.

In pharmacy, for the preservation of pills, to mix with many substances, in compounding prescriptions, and in more ways than can easily be remembered, glycerine now plays an important part.

In the arts it finds its way as the best wash for the interior of moulds in the casting of plaster figures, to prevent the gypsum from adhering to the sides of the mould.

In dyeing with some of our beautiful organic colors, glycerine is extensively employed with the best effect.

In chemistry it is used to prevent the precipitation of the heavy metals by the alkalies, and is thus a re-agent in analysis.

For making an extract of malt to improve or spoil, as the case may be, the beer manufactured in the usual way, glycerine has recently attracted a great deal of attention, and been the object of extensive speculations, if not of impositions upon the public.

In the preparation of *liqeurs* it has been found to be admirably adapted for preserving the characteristic flavors of these compounds, and it has consequently be-

come the great favorite of this class of manufacturers.

As glycerine is a remarkably stable compound, it is adapted to the preservation of wines, and this legitimate use of it has suggested to the adulterators of liquors an extensive fraud upon the community. Vast quantities of glycerine are annually manufactured, and as the known uses of it will not account for the consumption of more than a small fraction of what is made, it is difficult to explain the disappearance of the remainder. What takes place in the dark champagne vaults and cool subterranean wine cellars, evidently will not bear the light of day, and hence we neither see nor hear what becomes of the great stream of glycerine that is known to flow into them. Fortunately, it is not a poisonous substance, and its use for adulteration is consequently attended with less detriment to our stomachs than to our pockets. Whether the coming man will drink pure glycerine instead of wine, must be left for future consideration.

It has been discovered that glycerine can be fermented into alcohol with chalk and cheese, and it may be possible hereafter to manufacture alcohol in this way. The discovery is an important one,and may suggest some improved and cheap method for obtaining alcohol and acetic acid.

The last use of glycerine that we shall mention is, perhaps, the most important of all—its extensive application in the manufacture of nitro-glycerine. This explosive oil is made by treating glycerine with nitric and sulphuric acids in a peculiar manner. It has been known to chemists for some years, but it is only recently that a Swedish engineer has had the hardihood to propose it as a substitute for blasting powder. Its introduction has been attended with fatal consequences to many of the pioneers and earliest adventurers who have experimented upon its properties, but it is making rapid progress to public favor, and, in a few years, will, beyond all question, displace the old-fashioned blasting powder, and reign in its stead. By mixing the oil with sand, a solid explosive agent has been made, which is called dynamite. This is much less dangerous than the oil, and nearly as destructive in its effects, as it contains seventy-six per cent. of nitro-glycerine. A patent percussion-cap and safety-fuse is required for the explosion of dynamite, and, according to all accounts, it appears to be less dangerous than gunpowder.

The glycerine, which has come into notice within a few years, has become an article of great importance, and as its conquests are daily extending, we may expect to become very familiar with it, and to learn to appreciate it as another valuable contribution of chemical science to the ordinary wants of man.

SILT EMBANKMENTS.

From "Engineering."

Few of our readers are ignorant of the construction of the beaver dam, in which the economic employment of natural forces is adopted by the beaver, for the purpose of damming up the streams of rivers—an operation which,when undertaken by man, generally necessitates the employment of a vast number of laborers, much machinery, and great expense. The cost of such works in India has always been considerable, whilst there also exists a need of them far surpassing what is felt in any other country in the world. The monsoon seasons, during which part of the year alone does any great quantity of rain fall, invariably flood the rivers of India, their waters being carried away to the sea, leaving the parched land, during the dry season, without that supply of moisture which required only the work of man to store up during its abundance, against the time when its need is most felt. At the foot of all mountain ranges, whence most of the rivers derive their source, there exist many valleys which only require bunding across on one side in order to convert them into gigantic reservoirs, and which, being filled during the rains, would retain a sufficient supply of water to the rivers which formerly drained their catchment basins to maintain in them a running stream for the greater portion, if not for the whole, of the dry season, and which, by suitable arrangements, might be utilized for irrigating the adjoining lands, thus materially contributing to an increase of

the food supply of the country, at the same time that, by preventing floods at another portion of the year, the land would be protected from injury by inundations. The expense of such works has naturally led to their limited construction, whilst many parts of India are in urgent need of them. There has now, however, been in progress for nearly 18 months the experimental construction of an embankment by the "silting" process across the head waters of the Bhowany River, below the junction of the Porty and Avalanche nullahs, on the line of road which is being formed to connect the Neilgherry and Koondah hill ranges in the Madras Presidency; the result of which will not only shorten the distance by about 4 miles, but it will also inclose a vast reservoir, to be called Lake St. Lawrence, of capacity sufficient to supply irrigation to some 2,000 acres of land. This system of embankment formation was first brought to the notice of the Indian Government by Mr. W. G. McIvor, superintendent of the Government Chinchona Plantations at Ootacumund; and although the prineiplc met at first with much opposition from certain leading Government engineers, that gentleman was ultimately intrusted with the duty of carrying out the above-named work, as an experimental measure, under his own individual superintendence.

Twelve miles and a half from Ootacumund in a southwesterly direction, and near the Avalanche, is a stream of water called the Porty River. This stream flows through the valley between the Khoondahs and Neilgherry hills, and is the main branch of the Bhowany River, which, finding its way to the low country near Mettapolliem, and flowing through the Coimbatore district, empties itself into the Cauvery. This river winds its way between the hills, and at a point where, by their converging together, the valley between is narrowed, the embankment is being thrown across from hill to hill; it will be over a quarter of a mile in length at the top, and will rise to a height of 150 ft. above the level of the bed of the river, throwing back the water and forming a magnificent lake 5 miles in length by 2½ miles broad. Several hills which now appear of considerable magnitude will be submerged, and others rising to a greater height will show but their heads above water, dotting the lake here and there with islands. This lake will contain 30 million cubic yards of water, and to withstand its enormous pressure, the embankment at its base is 700 ft. thick. The estimated total cost of this gigantic work, including the construction of an under-sluice or culvert, is only 25,000 rupees, or £2,500.

The two requisites for this silting process are a stream of water above the level of the top of the intended embankment, and a supply of earth sufficient to form the dam. The nearest available hill supplies the latter, while one of the streams in use for the former purpose has been brought from a distance of about 10 miles. The hill to supply the earth having been selected, and the silting stream brought to the scene of operations, a trench some 6 ft. deep is cut along one side of the hill, which is continued by means of a narrow channel to the spot where the embankment is to be formed. At both ends of the intended bund a deep and wide trench is formed, extending from hill to hill and the earth thrown up on the outer side, or else the whole of the earth on the spot where the intended bund is to rest is taken away; the object being to remove the surface earth, roots of trees, etc., which on decaying would allow the water to percolate through the soil under the dam. In either case a low wall of earth is formed by heaping up the mud at either end of the intended bund, just sufficient to confine the water coming from the silting stream.

The water from the stream being turned over the hill-side, detaches the earth, which, falling to the bottom, is carried away in the trench to the spot where the bund is to be formed. Arrived here the silt-charged stream flows over the enclosed area, where, being ponded in, it deposits its burden, thus gradually raising the bund inch by inch in height, and the clear water is then allowed to flow away through a small orifice made in the mud wall at the opposite end of the bund. Thus the work is continued night and day, all the attention required being the services of a man to keep an outer wall of earth always slightly higher than the constantly rising bund, to prevent the immediate escape of the water and give time for the silt to deposit, and to bring the silting stream alternately into the opposite ends of the bund. The object of this latter operation being to make the bund of uniform

strength, for as the silt is the first to be deposited, that part of the bund where the stream enters receives the heavier particles, while the lighter sediment in suspension, taking a longer time to deposit, falls on the more distant part, and so by alternating the entrance and exit of the stream, silt and sediment are deposited evenly over the bund in alternate layers.

So far as the work has hitherto progressed, its success has been complete, and we learn that some of those engineers who previously doubted the soundness of the principle have now become willing converts. Upon the success, however, of the Neilgherry experiment—which may now be said to have been insured—there depends a still more important project. Besides the heavy rain-fall that deluges Travancore every southwest monsoon, the country to the sea is lavishly watered by rivers from the Western Ghauts, while Madura, on the other side of the water-shed, has few streams and less than 30 in. of rain. It is accordingly proposed to form a bund, by this silting process, across the channel of the Perriar flowing to the west, and thus to divert a portion of its current into the Vigay, a river in Madura, rising near the source of the Perriar in the Western Ghauts. This project, it is expected, will prove very costly; but the importance of the object is considered quite sufficient to warrant the outlay that will be necessary. In the words of Lord Napier, the main difficulty of the work "lies in the construction of a dam of unprecedented magnitude, partly in the bed of a furious torrent, and in a distant, deserted, fever-stricken region."

A YEAR'S STEAM BOILER EXPLOSIONS.

An interesting and elaborate report has been prepared by Mr. L. E. Fletcher, Chief Engineer to the Manchester Steam Users' Association, giving details of the boiler explosions which occurred during the year 1869. Referring first to the work of the Association, we find that during the past year 5,910 boiler examinations were made by the officers of the Association, 3,848 of these being external, 80 internal, 58 in the flues, and 1,924 entire. This is the highest number of entire examinations attained in one year in the Association's history; and, if added to the internal and flue examinations, it amounts to more than one for each boiler enrolled. The result of these examinations was that 1,331 defects were met with, 83 of them being dangerous, many of which would, if undiscovered, have ultimately led to explosion. On the whole, however, Mr. Fletcher reports that the general standard of boilers is improving, greater attention being paid to minor details, the importance of which is beginning to be realized.

Turning to the number of explosions that occurred during the year 1869, throughout the country, we find the total to be 58, by which 86 persons were killed and 126 others injured. If, however, to this be added the two kitchen boiler explosions and the two tar boiler explosions which occurred during the past year, the return for the year 1869 will be 62 explosions, resulting in 92 deaths, and 130 cases of injury. Explosions clearly are not on the decrease, as will be seen from the following table, which does not include those explosions which have sprung from kitchen, from ventilating, and tar boilers:

Return of the Number of Steam Boiler Explosions from the Year 1863 to 1869, inclusive, with the Number of Persons Killed and Injured thereby.

YEAR.	Number of Explosions.	Persons Killed.	Persons Injured.	Total.
1863	48	76	80	156
1864	32	64	90	154
1865	48	46	79	125
1866	72	87	109	196
1867	36	60	67	127
1868	45	57	60	117
1869	58	86	126	212
Total for 7 years	339	476	611	1,087
Average for each year.	48	68	7	155

From the foregoing table it will be seen that the number of explosions during 1869 was above the average, and supports the estimate given on previous occasions, that,

as a rule, one steam boiler explodes every week, or in round numbers 50 explode every year, killing 75 persons. As in previous years, the scene of the catastrophe has been visited in the majority of cases by officers of the Association, and the cause of the explosion investigated, full particulars being recorded at their offices. From these records Mr. Fletcher has prepared an elaborate tabular synopsis of the explosions that have occurred during the year 1869, which give the pith of the information respecting them. The length of this synopsis excludes it from our columns, but to the members of the Association, and in fact to all steam users, it will prove valuable as a record for reference as to cause and effect in these lamentable catastrophes. For further convenience, however, Mr. Fletcher has arranged the 58 explosions recorded in the tabular synopsis under three heads. One the service in which the boilers were engaged, another the general class or construction of the boiler in each case, and the third the causes from which the explosions sprung. These are given in the following tables :

TABLE NO. 1,

Showing the Service in which the Boilers were engaged from which Explosions arose in the Year 1869.

DESCRIPTION OF SERVICE.	Number of Explosions.	Persons Killed.	Persons Injured.
Collieries	16	20	21
Tin and other mines	10	2	2
Ironworks	5	15	11
Steamboats and Steam Tugs	4	17	10
Paper Mills	3	2	6
Agricultural	2	2	5
Locomotive	2	0	2
Iron Founders and Nail Cutters	2	2	4
Bobbin Turnery	1	15	33
Steam Crane	1	4	3
Cotton Mill	1	1	2
Woolen Mill	1	0	4
Miscellaneous :—1 Rice Mill ; 1 Saw Mill ; 1 Bleach Works ; 1 Brick Works ; 1 Chemical Works ; 1 Oil Works ; 1 Shipbuilding Works ; 1 Tin Works ; 1 Wire Works ; 1 Gun Implement Manufactory	10	6	23
Total	58	86	126

On a consultation of the above table it will be seen that more explosions occurred, as in previous years, at collieries, mines, and ironworks, than at any other works, while those at ironworks were of a much more fatal character than those either at mines or collieries. Numerous as cotton and woolen mills are, only one explosion occurred at a cotton mill, and one at a woolen mill. The following table shows the class of boiler from which explosions arose in the year 1869 :

TABLE NO. 2,

Showing the different Classes of Boiler from which Explosions arose in the Year 1869.

DESCRIPTION OF BOILER.	Number of Explosions.	Persons Killed.	Persons Injured.
Plain cylindrical, egg-ended, camber-ended, and flat-ended (externally fired)	21	20	38
Single-flued or Cornish (internally fired)	14	12	15
Double-flued or Lancashire (internally fired)	4	17	38
Multitubular marine type (internally fired)	4	17	10
Double furnace "breeches," and double furnace patent conical water tube (internally fired)	3	3	3
Portable, vertical, and locomotive type (internally fired)	3	5	8
Railway locomotive, multitubular (internally fired)	2	0	2
Furnace boilers, heated by flames passing of from iron furnaces :—			
One horizontal double-flued (internally fired)	1	2	6
One vertical (externally fired)	1	8	1
Wagon (externally fired)	1	0	2
Rag boiler (no fire, heated by steam)	1	1	2
Particulars not precisely ascertained	3	1	1
Total	58	86	126

On a consultation of the above table it will be seen that more explosions arose from, and more persons were killed by, the plain cylindrical, externally-fired class of boiler than any other. The introduction of the internally-fired Lancashire boiler in the place of the plain, cylindrical, externally-fired, would certainly be productive of safety, and it is thought, of economy.

All boiler explosions may, as a rule, be attributed to the neglect of the boiler maker, the boiler owner, or the boiler minder. Looking at the following table, it will be seen that 26 explosions were due to the boiler maker, 15 to the boiler owner, and 7 to the boiler minder. While

it is important that it should be known that a large proportion of the explosions that occur are due simply to bad boiler making, it should not be overlooked that the boiler maker is very much under the influence of the boiler owner, and, therefore, the responsibility must be shared between the two, which gives the boiler maker and the boiler owner together 41 explosions to answer for, against 7 by the boiler minder, or 6 to 1.

The third table shows the causes from which explosions arose in the year 1869 :

TABLE NO. 3,

Showing the Causes from which Explosions arose in the Year 1869.

Cause of Explosion.	Number of Explosions.	Persons Killed.	Persons Injured.
Malconstruction :—			
External firing.........11			
Collapse of flue tubes... 7			
Weak manholes........ 4			
Want of stays.......... 4	26	28	43
Defective condition :—			
External corrosion...... 8			
Internal corrosion...... 7	15	33	56
Overheating through shortness of water.........................	7	10	11
Overheating from the use of boiler compositions	1	0	0
Overheating—but cause of overheating requires further investigation.	1	11	7
Cases in which full particulars have not been obtained.............	8	4	9
Total	58	86	126

The above table shows how easily these explosions could have been prevented. The 11 explosions due to external firing could have been prevented by the adoption of the Lancashire boiler, in such general use in the cotton mills in this district, and from which so few explosions arise. The 7 cases of collapse of flue tubes might have been prevented simply by the addition of encircling hoops, flanged seams, or other suitable strengthening appliances. The 4 weak manholes could have been strengthened with mouthpieces. The 4 cases of want of stays could have been corrected by due calculation. The 15 plates wasted by external and internal corrosion might have been detected in time to have prevented explosion by competent examination, while the 7 cases of overheating through shortness of water, though due to neglect of attendants, might, in the majority of cases, if not in all, have been prevented by a liberal complement of fittings, and the adoption of a low-water safety-valve. Thus the causes of nearly all explosions are under control, and these disasters, as has been said on so many previous occasions, may, as a rule, be prevented by the exercise of common knowledge and common care.

Simple as the causes of these explosions were, the investigations conducted by coroners with regard to them were, in the majority of instances, most unsatisfactory, and the verdicts positively mischievous. Too frequently only incompetent witnesses were examined, and explosions resulting from glaring defects in the boilers were pronounced to be *inscrutable* and *inevitable ;* in consequence of which, boilers as deadly as those which had given rise to the explosions under consideration were allowed to be worked on without warning, at the peril of the lives of the poor men around them.

Constant reference to these subjects may appear monotonous, but those who are brought face to face with the devastation produced by these catastrophes are stirred with a strong sense of indignation at such evidence on these occasions. In one instance to which reference may be made, six persons were injured, one of them fatally, as well as a woman widowed and a family orphaned, simply by the explosion of a grossly malconstructed boiler ; yet, on an investigation by a learned coroner and his jury, the catastrophe was pronounced to be *accidental*, and every one connected with it acquitted of responsibility. The man was killed, and he must be buried, but it could not be helped, and there was an end of the whole matter. The owners were at perfect liberty to set to work another boiler, as defective, and, therefore, as deadly as the last, and to work on till another explosion should occur, and other men should be slaughtered, as well as others injured, other women widowed and other children orphaned ; when again, by the help of another learned coroner and his jury, the whole transaction would be once more condoned, the boiler pronounced good, the owners careful, and the only remaining duty declared to be to bury the dead out of sight of the living, and to go on as

before. Such is a simple recital of an almost every-day occurrence, and the question arises, how is it that such a state of things is allowed to exist? The answer is a simple one. Those who are killed are only poor stokers, who are too friendless and too ignorant to defend themselves. Let 75 boiler owners be blown to pieces this year instead of 75 of their firemen, and then boiler explosions would at once cease to be considered mysterious, the cause of each would become as clear as daylight, and their recurrence would be at once put a stop to. At all events, the Manchester Steam Users' Association is resolved to be clear in this matter. It has for years investigated the circumstances attending nearly every explosion that has occurred, and circulated broadcast sound information with regard to their cause. It has endeavored to sweep away all mystery with regard to this subject, and to show steam-users how to prevent the explosion of their boilers, and the slaughter of their workpeople; and as long as explosions continue to occur, from the use of glaringly malconstructed and old worn-out boilers, it will persist in circulating as widely as possible full particulars with regard to them, and in declaring that explosions generally are not the result of accident but simply of neglect, and that they might be and ought to be prevented.

SEWAGE AND THE LAND.

From "The Builder."

In the course of the discussion which followed the reading, by Mr. W. Hope, at the Society of Arts, of a paper "On the Use and Abuse of Town Sewage,"

Mr. R. Rawlinson, C.B., said he believed the most difficult land to irrigate would be a large area of comparatively flat land. He believed the most favorable was that having a limited contour elevation, and he should not even object to rather steep gradients in some instances, provided that the sewage at the commencement was sufficient for gravity, even if they had to go to some expense for pumping. His reason was this, that in irrigating land having a considerable fall, the engineer could pass his sewage by contour grips and lines over the upper areas, could then get it over the intervening portions into a second line of carriers, and as it was almost impossible to take out all the fertilizing qualities of sewage by once passing it over and through any table-land area, he could pass it over twice, thrice, or even four times beneficially, and he could then discharge the water from the last carriers as pure as ordinary spring water. He did not say they would ever arrive at that pitch of perfection when it would be safe to recommend the clarified water from subsoil drains for culinary and drinking purposes, although he knew at that moment of an instance in which the strongest sewage he ever heard or knew of was used by the adjoining residents in this way as it flowed from the subsoil drains, and that was at the farm at Aldershott; and as this was the most perfect system of sewage irrigation that had come under his observation, a word or two in description of it might be allowed. It was perfect in every respect, not only because the difficulties overcome were the greatest, and the sewage by far the strongest, but because the results were by far the best. The Aldershott Camp Sewage Farm consisted of about 98 acres of land, which was, as an old north country farmer once said, worth "nowt" an acre. It was absolutely worthless, consisting of 90 per cent. of sand, with a mixture of peroxide of iron, which was absolutely poisonous. Mr. Blackburn, the engineer who had charge of the works, and who, fortunately, had had some experience in agriculture, broke up the subsoil, washed out the peroxide of iron, drained it, and laid it under a sewage irrigation of from 200,000 to 400,000 gals. per day, the sewage coming from the camp, and containing 20 grains of ammonia in the gallon; and an analysis showed that, while it had 20 grains of strong phosphoric acid to the gallon as it flowed on the land, the water from the subsoil drains only had half a grain. Mr. Blackburn said it was of no use to irrigate land with sewage on the surface, or to plough it in the ordinary way; he invented a plough for the special purpose, and broke up the subsoil to a depth of 20 in., and having

irrigated that well with sewage, he got a crop of Italian rye grass of from 70 to 80 tons to the acre. After two years he laid down a breadth in potatoes, which he sold on the ground at £25 per acre, the purchaser being at the cost of digging and taking them away, and leaving the tops behind as a solid dressing for the land of considerable value. In the same autumn the land was broken up, prepared and sown with Italian rye grass, which he himself saw showing 2 in. above the surface. If, however, a good profit was to be made out of land irrigated with sewage in the vicinity of a town, it should be made to produce every kind of garden produce used in the community, all kinds of grain crops being avoided, as entailing only waste of labor, land, and money. Italian rye grass, mangolds, potatoes, cabbages, French beans, and lettuces, could all be grown with advantage, but they required special knowledge and special care; for some must not be irrigated at all while the crop was in the ground, whilst others required quite a different treatment. In this way as much as from £100 to £200 per acre of gross receipts might be obtained, for he had seen a return made by persons on whom he could place implicit confidence, showing with a crop of cabbages and cabbage-plants a gross return equal to £200 per acre. Between this and the ordinary produce of £5 to £10 per acre was a wide margin, quite sufficient to induce efforts in this direction. They were on the threshold of this question, and only just beginning to understand it; and as there had been so much joint-stock enterprise of late, he would suggest to any gentlemen who wished to make their fortunes that they could not do better than form an honest company and go to some of the distressed towns which had been described as in the clutches of the Vice-Chancellor, and treat with them for their sewage and the land necessary to utilize it. He knew many towns which would receive them with open arms, and let them have the land at a fair agricultural price, and let them have the sewage in for nothing; and if there was any truth in chemistry, this could hardly be a bad bargain. But, at the same time, it must be conducted with knowledge and care, for he himself was concerned in a speculation of that kind where both the sewage and the land were as good as any in England, and the climate propitious; but, owing to defective management in some way, they only got a dividend of 1½ per cent., whereas, by letting it in the ordinary way, having bought it on good terms, they could have realized 5 per cent. There were, therefore, two sides to the sewage shield, as to most others; but he believed, nevertheless, that in the proper application of this system there was a mine of wealth, by bringing common sense to bear, and avoiding blunders which had already been committed. On the other hand, in many places it had become a sheer necessity to do something of this sort, in order to avoid poisoning the rivers, and would be more and more so every day. Before sitting down, he would say that the man who could solidify sewage and make it a portable manure, could invent perpetual motion and square the circle. The most perfect chemical researches had yet failed to do more than take out one-seventh of the valuable properties of sewage in solid form; and taking a ton of sewage as being worth 17s. 6d., and treating it in any possible way—and he spoke from having been associated on the Commission with some of the first chemists of the day—the result would be to take out solid matter to the value of 2s. 2d., and leave 15s. 4d. worth to go away with the effluent water, which might nevertheless appear perfectly pure and bright. On the other hand, when liquid sewage was passed through 20 in. of soil, it had but the barest trace of these valuable salts left in it. This, therefore, was the only true and profitable chemistry.

STEEL BOILER.—At the Fort Pitt Iron-works, Pittsburg, Pa., a cylindrical boiler was constructed last year of steel plates ½ in. in thickness, by that establishment, for the Government, with a view to testing its adaptability to such use, relatively with the iron. It was tested with cold water in presence of the proprietors of the works, the Government engineer officer—under whose supervision it was built—the eminent constructing and mechanical engineer Thatcher Perkins, and others. Measurement of the girth of the boiler was made, with a steel tape, before and during the process of pumping in cold water, and when the pressure reached 780 lbs. an enlargement of 3¾ in. was found to exist, and at 820 lbs. rupture occurred.

DE-RAILMENT OF RAILWAY TRAINS.

From "Engineering."

All engineers who have had experience in railway management are familiar with cases in which accidents have arisen from engines or carriages leaving the line without, apparently, any sufficient reason. No doubt in the vast majority of instances, when a train leaves the line, there is evidence to prove why the de-railment took place; but this is not always the case—and in many an instance the subsequent investigations which have been made have failed to show the causes which led to the accident. Now, an accident which is accounted for is bad enough; but an accident which is unaccounted for is far worse, for in the latter case no experience is gained which may lead to the avoidance of a disaster in future. For this reason we consider that whenever a mishap of the kind of which we are speaking occurs, no trouble should be spared in determining, if possible, its real cause; and if this cause is one which is not generally known, information concerning it should be disseminated amongst those whom it interests. It has been often stated that a record of engineering failures would be more instructive than an account of engineering successes, and to no class of failures does this remark apply more truly than to railway accidents.

We have said that there have been many instances in which trains have left the line without, apparently, any sufficient reason, and it is of this class of railway accidents that we wish to speak here. And, first, as to the ordinary causes of derailment. These are: Weak or uneven permanent way, bad joints, wheels with flanges worn to a sharp edge on the outer side, and curves worked by engines or vehicles unfitted to pass round them. Where any one of these causes exists there is no difficulty in accounting for a case of de-railment; but when none of these are present—when the permanent way and wheels are in good order, the speed of the train not excessive, and when the accident does not occur on a curve—we have to search further for the causes which give rise to the mishap. When a train is running at a fair speed on an ordinary line of railway, the rails receive a succession of lateral blowsfrom the wheel flanges; these blows—which are more or less severe according to the state of the road and the construction of the rolling stock—being nothing but a series of endeavors on the part of the train to "run off." Now, supposing the tyres and permanent way to be in good order, and the line to be straight, "running off" can only occur when the force with which any wheel flange strikes the rail laterally is sufficient to cause that flange to act as a kind of inclined plane, lifting the weight resting on that wheel and thus causing "mounting." It may at first sight appear that, considering the forms of tyre and rail section in ordinary use, no amount of lateral force which is likely to be available would suffice to cause the lifting of the weight upon the wheel in the manner we have just mentioned; but a little further investigation of the case will show that the possibility of such an action certainly exists. Let iron templates of ordinary tyre and rail sections be taken and placed together in the manner in which a wheel bears upon a rail, and let a pressure be then applied to the inner edge of the tyre template, when it will be seen that the latter can be readily made to rise from its bearing upon the rail. In the case of an ordinary engine or carriage, this mounting under the influence of lateral pressure is prevented by the weight insistent upon the wheel, and we thus see that in the steady maintenance of this weight lies one of the principal safeguards against de-railment.

This brings us to the question as to how much the insistent weight upon the wheels of an engine or carriage varies when running at moderately high speeds; and this is a question to which no precise answer can be given. That the load on the wheels does vary—and vary considerably too—is clearly shown by the play of the springs; but the degree of maximum variation depends so greatly upon the construction of the rolling stock, the manner in which it is loaded, and the state of the permanent way, that not even a general statement of its amount can be given. That, however, this variation is in many cases very far greater than is usually supposed, is proved by some interesting experiments on the subject which have been made by M. de

Weber, of the State Railway of Saxony. These experiments, which have been made, by the aid of suitable arrangements, on six-wheeled engines, having, we believe, all the axles under the barrel of the boiler, show very startling results. They show that in the case of trailing wheels carrying a normal load of 5¾ tons each, the load when running varied from 10 tons down to 1½ tons; while in the case of leading wheels having each a normal load of 3½ tons, the load when running varied from 8 tons down to zero! Now, although we should hope that such an occurrence as the total removal of the load from one of the leading wheels of an engine is an exceptional one, yet the fact that it occurred during M. de Weber's experiments proves that it is likely to occur again under certain conditions; and it is certainly more than probable that if this removal of the load took place simultaneously with a severe lateral blow of the flange of the wheel against the rail, "running off" would be the result. M. de Weber's experiments, in fact, go to show that most of the "mysterious" de-railments which have occurred have probably been due to this simultaneous occurrence of a severe lateral pressure, and an upward oscillation of the load on the springs of the particular wheel which has mounted, this action being in many instances further assisted by one of which we shall now proceed to speak.

In addition to his experiments on the variation of load on wheels of engines when running, M. de Weber has made a number of others on the lateral stability of permanent way, and although these experiments were carried out on the somewhat light rails of the State Railway of Saxony, the results obtained possess considerable general interest. When a line of rails is subjected to a lateral pressure, applied to the side of the head of the rail at any one point, it may yield by the flexure of the rail itself, by the turning of the rail on its base, or by the direct movement of the sleepers on the ballast; and as far as the two last mentioned causes are concerned, it will be found that the amount of yielding which will take place will be greatly modified according to the load which the rail is carrying at the time when the lateral pressure is applied. Thus, M. de Weber found that the resistance of the sleepers to lateral movements on the ballast was increased tenfold, as compared with the same line unloaded, by the imposition of a load of 28 tons; while in the case of the Vignoles rails, on which the experiments were tried, a force of 2¾ tons, which produced an enlargement of the gauge to the extent of 1⅛ in. when the line was unloaded, produced a spreading of but ⅛ in. only when the rails were carrying a load of 11 tons on a pair of wheels. These results show that the relieving of the wheels of weight by the vertical oscillations not only facilitates mounting, but also diminishes the lateral resistance of the rails to a spreading of the gauge, and it thus tends to produce de-railment in two ways. M. de Weber's experiments thus go very far to explain the cases of "running off," which are not accounted for by ordinary causes, and we should be glad to see them followed up by similar experiments on the engines and forms of permanent ways in general use in this country.

MARBLES.—The chief place of the manufacture of marbles is at Oberstein, on the Nahe, in Germany, where there are large agate mills and quarries, the refuse of which is carefully turned to good paying account by being made into the small balls employed by experts to knuckle with, which are mostly sent to the American market. The substance used in Saxony is a hard, calcareous stone, which is first broken into blocks, nearly square by blows with a hammer. These are thrown by the 100 or 200 into a small sort of mill, which is formed of a flat, stationary slab of stone, with a number of concentric furrows upon its face. A block of oak or other hard wood, of the same diametric size, is placed over the small stones and partly resting upon them. This block, or log, is kept revolving while water flows upon the stone slab. In about 15 minutes the stones are turned into spheres, and then, being fit for sale, are henceforth called "marbles." One establishment, containing only three of these rude mills, will turn out full 60,000 marbles in each week. Agates are made into marbles at Oberstein, by first chipping the pieces nearly round with a hammer, handled by a skilful workman, and then wearing down the edges upon the surface of a large grindstone.

THE MANUFACTURE OF STEEL.*

From "The Journal of Applied Chemistry."

It is hardly necessary to say that this is the most complete, accurate, and valuable treatise on the metallurgy of steel that has been published at any time, in any language. Prof. Kerl put into the book the results of his patient study of the subject, and the English editors have contributed the latest improvements and newest practical information from the immense iron workers of Great Britain. We have in this way the best possible combination for a complete work on the subject. The printing, paper, and illustrations are in harmony with the thorough and comprehensive design of the book, and it is with unalloyed satisfaction that we apply ourselves to the task of reviewing it.

We cannot do better at the outset than to quote a few words from the preface. The authors say: "Owing to the complexity and vastness of the subject, and to the continued development of new processes and inventions, the task of the authors has proved by no means easy, but they trust that they have succeeded in producing, in a compendious and somewhat complete form, a work of practical value to the metallurgist. While the authors have taken the admirable treatise of Prof. Kerl as the groundwork of their labors, they have given much practical information and many useful processes, which are not to be found in Kerl." A glossary of technical terms and tables of weights and measures are given at the end of the volume.

The book opens with a definition of steel: "Steel differs from pig and wrought iron in its proportion of carbon (1.4 or 1.5 per cent.); it differs from pig-iron in its property of welding, and from wrought-iron in its fusibility; its melting point is about 1850 deg. C., whilst the melting point of pig-iron is between 1400 deg. and 1600 deg. C. Steel is furthermore characterized by its softness at a glowing heat, and by becoming hard upon sudden cooling. These properties are modified according to the proportion of carbon, the presence or absence of certain foreign admixtures, the uniformity of its mechanical treatment, the method employed for its production, and finally, to other circumstances which are not yet well understood."

PROPERTIES OF STEEL.

"Steel is whitish gray, or white and dull, with a silky fracture; its texture is fine-grained, the grain being of an indefinite, jagged shape, and somewhat lighter and finer in tempered steel than in soft steel. Tungsten steel shows a perfectly conchoidal fracture on which the grain is so fine as to be scarcely preceptible. Natural steel in the original balls, and cement steel after cementation, as well as cast-steel immediately after being cast, shows a coarse non-uniform appearance, and has but little tenacity; but the grain will become finer if the steel is drawn out at suitable temperatures to very small dimensions; and if a very high temperature has been employed in its tempering, slowly cooled steel maintains its original texture, and hardened steel retains it if re-heated, and slowly cooled. This circumstance must be taken into consideration when judging the quality of steel from the appearance of the fracture, as steel is usually considered to be of a superior quality if its grain is very fine. The appearance of the fracture may prove the uniformity of steel, but does not indicate its other properties—hardness, tenacity, etc. These qualities depend on the quality and quantity of the foreign admixtures contained in the steel, and can only be detected by direct trials and tests.

"The specific gravity of steel ranges between 7.5 and 8.0, and is diminished by hardening. The following table shows the specific gravity of Bessemer steel of various degrees of carbonization made at Sandviken in Sweden:

SPECIFIC GRAVITY

Percentage of Carbon.	Soft.	Hardened.
1.5	7.785	7.736
1.2	7.832	7.771
0.9	7.874	7.808
0.6	7.879	7.807
0.4	7.893	7.839

"The hardness of steel varies with its

* A Practical Treatise on Metallurgy; adapted from the last German edition of Prof. Kerl's Metallurgy. By William Crookes, F. R. S., and Ernst Roehrig, Ph. D., M. E. In three volumes. Vol. III. Steel; Fuel, Supplement. Illustrated with 145 wood engravings. Royal 8vo., pp. xxxii., 820. John Wiley & Son, 2 Clinton Hall, Astor Place, New York. 1870. For sale by Van Nostrand.

proportion of carbon. The steel poorest in carbon is the least hard, and the steel richest in carbon approaches white pig-iron; but its other properties, strength, fusibility, weldability, etc., are then modified. Unhardened steel with the proper amount of carbon, 1.4 or 1.5 per cent., is but little harder than wrought-iron. The tensile strength of steel considerably exceeds that of wrought-iron. The transverse strength is likewise very great, and the crushing strength varies with the hardness of the steel.

"The influence of foreign substances upon steel is in many cases unfavorable, chiefly by impairing its tenacity and elasticity; this influence is exerted by sulphur, phosphorus, silicon, copper, etc.; other substances have a favorable influence, but it is still doubtful whether they always enter into combination with the steel, or merely have a purifying effect by combining with the injurious substances present, and thus separating them, as is the case with pig-iron. Manganese facilitates the formation of steel, and purifies it, although only a little enters the steel in combination. Tungsten steel shows an exceedingly fine, conchoidal, silk-like fracture, combining great hardness and density, and is superior in tenacity and weldability to all other steel. Notwithstanding its reputed qualities, tungsten steel has not been generally introduced, probably owing to the high price or the scarcity of wolfram. Perhaps steel was sold as tungsten, which did not contain any tungsten, or else its reputed qualities are somewhat exaggerated.

"According to Mr. Musket, titanium acts upon steel in the same way as tungsten, when titaniferous iron ores, or other iron ores, with titaniferous fluxes, are smelted for the production of grey pig iron (not white pig, as in this case the most titanium will enter the slag), and the grey pig iron is worked into natural or cement steel. More recent observations show that titanium, as well as tungsten, seems to enter steel in larger proportions, and to improve its quality."

After giving very fully the properties of steel from which we have condensed the above statement, the authors enter upon a description of its manufacture in various countries, and according to different processes. They then devote a large portion of the work to the discussion of the important question of fuel and the utilization of waste gases; and finally, in the supplement is contained a rich store of matter, from which we shall hereafter make copious extracts for the benefit of such of our readers as cannot afford to purchase the book. We regret to be obliged to say that considerable carelessness has been shown in the choice of language in the translation of many passages; but as the facts are accurately given, the language in which they are clothed must be of secondary importance.

TRIAL TRIP OF A FAIRLIE ENGINE.—The Burry Port and Gwendraeth Railway is the first construction under the recent Act of Parliament, which enables a railway company to lay a light rail for the permanent way, and is quite an experiment in light and cheap railways. The above-named company, in order to protect their permanent way as far as possible, have purchased a new engine built on the bogie principle adapted to locomotives and railway carriages, by Mr. Fairlie. Her cylinders are 10 ft.; each boiler is 9 ft. long, and 2 ft. 11 in. diameter inside, and contains 168 tubes; the fire-box is 5 ft. long; the wheel base is 5 ft. and the diameter of the wheel 3 ft. 6 in.; length of tube 18 in.; and length of engine 33 ft. The trial trip was made on Wednesday, on the line from Pembrey to Portyberem, a distance of 11 miles. The weight of the train was 150 tons 17 cwt., and of the engine 23 tons 10 cwt., making a total of 174 tons 7 cwt. The engine started from a state of rest at the bottom of an incline of 1 in 36, and 14 chains long. This she failed to ascend at first, owing to the slippery state of the rails, but a little sand being applied she went up easily. She pushed on very well for 8 miles 34 chains, which is a continually rising gradient. The distance was traversed between 12.23, the time of starting, and 12.49. At this point of the line there is an incline of 1 in 45, which she failed to ascend with three attempts; the pressure was then raised to 100 lbs., 48 tons 8 cwt. were taken off, and she ascended the incline easily. The coal used was said to be small and choked the tubes. She was considered by a number of practical gentlemen who were present to be equal to a load of 120 tons up an incline of 1 in 45, and will probably go from 17 to 20 miles an hour. The trial was very satisfactory.—*Engineering.*

STEEL FOR TOOLS.

We extract from "Engineering" the following remarks in regard to Mr. Robert Mushet's "special steel," manufactured by the Titanic Steel and Iron Company, of Coleford, and a very peculiar material it is. Of the process of its manufacture we know nothing; but of the quality of the material itself when used as a cutting tool we have latterly had an opportunity of judging, and we have been led to form a high opinion of it. One of its main peculiarities is that it does not require hardening, or rather, to speak more correctly, that it only requires hardening by a light cold-hammering, and not by dipping in the ordinary way. A fractured bar, when examined by the microscope, shows a remarkably close and even texture, the grain in fact being so fine that it is barely distinguishable by the naked eye. When heated to a low red heat it can be forged without any great difficulty; but like all good tool steel it requires care on the part of the smith, and a bar should not be drawn down much without reheating. When a tool has been brought to the required shape it should be lightly but thoroughly cold-hammered, and then put aside to cool gradually. When cold it only requires grinding to be fit for use.

Amongst the firms who are now using Mr. Mushet's steel extensively are Messrs. John Fowler and Co., of the Steam Plough Works, Leeds; and it was at their works that we last week had an opportunity of seeing a number of these "unhardened" tools in use. Messrs. Fowler, as is well known, use steel forgings and castings very extensively in the construction of their engines—in fact we do not hesitate to say that their requirements alone have given a most important impetus to the manufacture of such castings in this country—and the quality of the tool steel they employ is thus to them a matter of considerable importance. The taking a slight cut, scarcely more than skin deep, off the inner faces of the deep flanges of the steel winding drums, and the series of intermittent cuts which have to be taken in turning up the faces left on the arms of these drums, etc., are pieces of work which test the quality of tools as much as it is perhaps possible to test it, many of the castings notwithstanding the annealing to which they are subjected having skins so hard, particularly in the angles, that it is with difficulty a tool can be got to act upon them at all. It is for this class of work that Messrs. Fowler are now using Mr. Mushet's steel, and they are gradually replacing all their lathe and planing machine tools with this material. At a planing machine we found some of these tools in use planing locomotive coupling rods (iron), about 7ft. long, between centres, the average work done by each tool, without grinding, being to take a finishing cut over all sides of one rod, and a similar roughing cut over the next; while at an adjacent machine was a tool which had been in use planing for seventeen hours without requiring to be taken to the grindstone. Similar tools had been planing cast-iron fifteen hours, and turning steel axles six hours—the surface speed of the axle being 20 ft. per minute; while one tool had been planing steel horn-blocks twenty-five hours. Perhaps, however, the best evidence of the value of this material is to be found in the behavior of the machine men at the Steam Plough Works, who are all on piecework, and who, when turning or planing steel, invariably use the tools of which we have been speaking, if they can possibly get them, as they enable them to run their machines at a higher speed, and avoid loss of time in grinding and making changes. So far we have only spoken of the value of the material when used for operating on steel; but the same qualities which give it value in this case render it equally valuable for turning or planing wrought or cast-iron. For chisels or other tools operating by a percussive action it is not suitable, as, although not objectionably brittle, it is not of such a nature as to bear blows well. Of its adaptability for drills we have no experience, but there is such an ample field for its employment in other forms that it is of little consequence whether it makes good drills or not. In conclusion we may state that we have spoken of Mr. Mushet's "special steel" at some length, because we regard it as a very peculiar and valuable material, the properties of which deserve to be even more widely known than

they now are, and which, we believe, only requires to be fairly treated to gain a reputation which will lead to its extensive employment for turning and planing tools in all establishments where there is hard work to be done.

THE STONEWORK OF THE HOUSES OF PARLIAMENT.

From the "Pall Mall Gazette," through the "Building News."

The condition of the stonework of the New Houses of Parliament is at last beginning to attract serious attention. When pieces of masonry varying in weight from 5 lbs. to 10 lbs. or 15 lbs. come crashing down, it is no wonder that some uneasiness should be felt, at least by those who reside in the Palace, or whose duties take them thither. Only a short time since a piece of carved work, weighing between 70 lbs. and 80 lbs., fell from the summit of the Clock Tower upon the roof of the house below, inhabited by the record clerk of the House of Commons, Sir Thomas May. It passed through the iron roof as if it were so much paper, broke an iron girder, and was stopped only by the stout brick arches beneath. Another time a piece of about 18 lbs. weight fell into one of the courts and was shivered into fragments just after no less a personage than the Usher of the Black Rod had passed through. At another time a fragment weighing about 10 lbs. fell at the feet of the policeman on duty outside the entrance into Westminster Hall, at the south end, just opposite the Abbey. During every considerable storm a shower of pieces of stone, from the size of a walnut to an orange, rattle down upon the iron roofs. We believe, indeed, there is a special functionary appointed to go about the roofs and rake the débris into heaps. There is never any certainty as to when or where these sculptured morsels are going to fall; and the River Terrace, where on summer nights the members walk and smoke their cigars, is not likely this year to be so much frequented as usual. More pieces break off from the carved terminals supporting the gilt vanes than from any other parts; the reason being that the rods which carry the vanes are of iron instead of copper, and as the iron oxidizes it swells and splits the stone. In no remote time this defect is likely to cause the destruction of the upper parts of all the pinnacles. The only change likely to do much good is to substitute copper rods for the rods of iron. Besides this, the stone is rotting deeply in broad discolored patches, in regular lines all round what are called the string courses. Before it has been forty years in existence the New Palace of Westminster shows far greater signs of external decay than many structures of ten times its age. Certainly if reports, inquiries, commissions, and committees could have done any good, the New Houses of Parliament ought to have been about the soundest buildings ever reared. In the first instance a commission of scientific men and architects was appointed to ascertain the best kind of stone to be employed. These commissioners must have had what the Americans call a good time of it in prosecuting their inquiries, for they appear to have visited every castle, abbey, and ancient house in England. In the end they recommended the use of a magnesian limestone, geologically called dolomite, which abounds in Derbyshire, and of which Bolsover Castle, still in fine preservation, though of the date of 1680, is built. So various is the quality of this stone that the same quarry will furnish the best and closest-grained seams and the most porous and most worthless. Sir Charles Barry, we believe, wished that an experienced practical man should be appointed to examine all blocks sent from the quarries. But the Government did not see the necessity of this recommendation, and the post was never properly filled. Two quarries were selected in Derbyshire—the Mansfield and the Anston. The former, unfortunately, could only furnish a small supply, but what it yielded was of excellent quality. The Anston quarry had an abundant supply, and of this the New Palace is mainly built. The difference between the two kinds of stone is now as easily distinguishable in the external walls of the building as the difference between brick and marble. The Mansfield stone is as sharp and

true in outline as when it left the mason's hand; the Anston stone in all exposed positions is fast rotting away. Experiments which have been made show that some of the stone employed is of a most porous kind; indeed, a cube of stone nine inches square was found to be capable of absorbing no less than three pints of water in forty-eight hours. How many gallons, then, would the whole building absorb during two or three days' heavy rain? and what must be the result when in winter the rain is followed by a frost expanding the absorbed water into ice? As a matter of course the delicate carvings must crack into splinters. The process of decay is thus going on steadily and swiftly, and some remedy should be immediately applied. The report recommending the material to be employed in building the New Palace dwells upon the necessity of special care being taken in the selection of stones for the west and south-west faces, as there it says the greatest tendency to decay would always be found to exist. Upon what evidence this theory was based we do not know, but the exact reverse of what was predicted has happened, for it is in the east and north-east faces that the stone has most rapidly decayed. One can, in fact, draw a series of lines round the building where the stones are rotting, and these lines will be found to correspond with what are technically called the string courses, that is, the stone mouldings which project above and below the bands of carved work. Upon these the water drips from above, and then trickles over to those beneath, and so on from top to bottom, till the constant dropping wears away the stone, and the inscriptions are becoming illegible, and the little pinnacle carvings falling away. The same process has gone on, but not to so great an extent, at the Geological Museum in Jermyn street, though the stones of that building, as might have been expected, were carefully examined when selected. It is to be feared, however, that most kinds of dolomite are too porous to withstand the London climate in their natural state. Their pores require closing to protect the surface from the action of moisture, the destructive effect of which is increased by the sulphureous acid which is generated in the London atmosphere by the hundreds of thousands of coal fires always burning. The Caen stone endures our climate better, as we see in Westminster Abbey—much of the east end of which is built of this material; but the Mansfield stone appears to be the best of all in this respect.

Of course when the stonework began to decay, as it did before the New Houses were half finished, the methods proposed for its preservation were almost innumerable, some of them virtually amounting to a plan for rebuilding the whole structure. The favorite device, however, was to coat the stone with various liquid compositions, so as to fill up its pores, and keep them air and water-tight. About twelve years ago two of these inventions were tried on portions of the walls. One was a liquid prepared by Mr. Ransome; another was a solution of silica, the invention of Mr. Szerelmey, a practical chemist, who has devoted his scientific knowledge to the discovery of preservatives against the decay of stone, wood, and iron. A committee, consisting among others of the late Prof. Faraday, the late Sir Charles Barry, and Sir Roderick Murchison, was appointed to decide upon the merits of the competing inventions, and its verdict was in favor of Mr. Szerelmey's plan. The test of time apparently confirms the judgment of the committee, and the composition which it recommended has, after a lapse of 11 years, been re-examined. During the interval that has passed it has been severely tried, having, we believe, been scrubbed with wire brushes and with sand and sulphuric acid. Yet it remains as bright and vitreous as when first put on during a heavy shower of rain. Among other things petroleum, and what is called liquid glass, have also been tried. The petroleum makes the stones look black and greasy, but still it must to some extent fill up the pores, and so for a time retard decay, just as, we believe, the boiled linseed oil has done when applied to the Geological Museum in Jermyn street. As to the water-glass, it is strange that any practical chemist could have thought of it for such a purpose. Water-glass is only silicate of soda. If all the stonework could be immersed in this for a year or so it would form on the outside a silicate of lime—hard and durable enough for all time. As it is, it has merely been smeared on with a brush like any other paint or solution. The carbonic acid in the air

turns the silicate of soda into carbonate of soda, producing a mouldy efflorescence which is easily wiped off with the hand, and leaves the stone as exposed to decay as ever.

Besides these various compositions, another mode of treatment is now, we believe, being pressed upon the attention of the Chief Commissioner of Works. This is nothing less than the cutting out of the decayed parts of the masonry and the substitution of stones of a better quality—in other words, the rebuilding of a considerable part of the Palace. In the end perhaps this remedy may prove to be the only effectual one, but it is obviously a remedy of a very desperate character, and ought unquestionably to be adopted only after all other measures have been fairly tried and failed. We certainly do not think it can be said that this has yet happened. Indeed, there is very strong practical and scientific evidence in favor of at least one of the protective compositions which have been already tried. The plan of cutting out the decayed stones would be very costly—in fact, the cost would be indefinite; once begun it would be difficult to say where it should stop. It is perfectly plain, however, that the present condition of the Palace of Westminster is not only disgraceful, but even dangerous.

MOUNTAIN LOCOMOTIVES.

A correspondent of "Engineering" gives in a recent letter the following interesting details respecting the work of locomotives on heavy grades :—

As a distinct specialty of railway working, mountain railways present some special features, involving a modified mode of transport by steam power. Locomotives cannot be adapted to the exceptional exigencies of undulated lines without sacrificing either speed or train load ; the tendency is, and will always be, to maintain this latter as high as possible; a great tractive effort must therefore be produced and utilized at reduced velocity; the speed being also limited, on the other hand, by the smallness of the driving-wheels and small curves. In ordinary locomotives the tractive force, or the "cylinder power," amounts usually to $\frac{1}{7}$ of the weight on the driving-wheels, and this proportion is well justified by experience, as will be seen presently. Upon a clean dry rail a maximum coefficient of adhesion of $\frac{1}{6}$ and even $\frac{1}{5}$ is occasionally attained; but in the course of prolonged working, such an adhesion could not be maintained. In good weather, however, a co-efficient of $\frac{1}{7}$ may safely be counted upon as a normal value, while in winter time the friction is, of course, considerably less. On the Continent, the most precise and reliable information on this subject has recently been furnished by MM. Vuillemin, Guebhard, and Dieudonné, engineers to the Eastern Railway of France. The results of a long series of experiments, made with a traction dynamometer, have been published in a memoir, entitled "De la Resistance des Trains et de la Puissance des Machines." Paris, 1868. Eugéne Lacroix, éditeur. This is a work of great value, and has, as such, obtained the Perdonnet Medal of £80, offered by the late M. Auguste Perdonnet to the Society of Civil Engineers of France, with a view to stimulate such researches. As regards locomotive adhesion, we find in Tables 24 and 25 of this memoir a summary of observations, made with various types of engines and trains, and from these results it appears that, during continued work, the maximum value of the coefficient of adhesion was $\frac{1}{7}$; upon this limit should be based, according to the authors, the maximum train load which an engine can haul in good weather ; to rate, on the other hand, the capabilities of an engine in all sorts of weather, and especially in winter time, no greater co-efficient than $\frac{1}{8}$ should be counted upon. In the same tables a superior co-efficient than $\frac{1}{7}$ is noted down also, but this occurred while starting at a station, a case where the limit of adhesion—by the exertion of an instantaneous effort—is always closely approached. I may mention that the coefficient of adhesion is sometimes quoted as a kind of "figure of merit," in comparing the useful effect of different engines working different lines ; but if the train resistances are not precisely known, and "guessed at" only, this manner of rating is very apt to mislead. During the above

trials, however, the tractive force was registered constantly by the traction dynamometer; the power absorbed in moving the engine having also been ascertained previously in a similar manner, the total tangential effort, or the gripping friction between tyre and rail, corresponding to a certain fraction of the adhesive weight, was thus correctly known.

On mountain lines, locomotives are generally worked up to their maximum adhesive power, hence frequent slipping. On the Semmering an adhesion from $\frac{1}{8}$ to $\frac{1}{7}$—a very favorable figure, considering all the circumstances—is usually maintained, whereas on the Giovi the ruling coefficient amounts to but $\frac{1}{10}$. It is thus evident that in a well-proportioned mountain engine, the ratio between "cylinder power" and adhesive weight may differ widely from what experience has established in ordinary practice.

Proceeding now to the actual working of the great mountain railways in the Alps and the Apennines, I shall not attempt to establish a comparison between the results and the useful effect obtained with various types of engines; to do this without prejudice, many elements—besides the configuration of the line—would have to be known and taken account of, such as the state of the rails, the construction of the rolling-stock, the intensity and direction of the wind, the surface of the wagons, the length of trains, the dimensions of bearings and of wheels, the wheel bases, the nature of lubrification, the temperature, the mode of coupling, the manner of loading, or the proportion of net to gross load, etc. What I intend recording, with reference to engine performances, comprises simply some personal observations, aided by the information of railroad superintendents, running shed foremen, and engine drivers.

1. The Semmering, although preceded by the working of steep gradients on American railways, and by valuable experience gained in the Fichtelgebirge, may truly be termed the Rainhill of mountain railways. True, there was no gallant George Stephenson, but there a glorious edifice was built on his foundation-stone, and followed since by works of still greater magnitude. On the mountain passes of those majestic Alps, where once great warriors of by-gone ages led on their armies, are now fighting the modern Hannibals, the Charlemagnes, and Napoleons, leaving their footprints in the everlasting rock! It would occupy too much of your space, sir, were I to draw a historical outline of the Semmering contest in 1851, but those of your readers who feel interested on this subject may find ample and impartial information in "Engineering," vol. i., p. 57, and specially in a memoir by M. Fouche, entitled: "Des progrés des machines locomotives et de leur influence sur les conditions de l'établissement des chemins de fer." Paris, 1852. The period, following the opening of the Semmering up to the present date, occupies likewise a conspicuous place in locomotive history. Up to 1868, the heavy goods trains were always divided into several portions at the foot of the incline; each portion was taken over the mountain by a single engine, the employment of two engines having not been found advisable. In the spring of 1868 a serious accident occurred on the gradient, owing to the breakage of a coupling; it thus happened that a portion of the leading goods train fell back upon another train, following at a short distance. This occurrence led ultimately to the application of "double traction" in the shape of a "head" and a "tail" engine, as now introduced on nearly all mountain lines; and this system, having undergone a serious trial over the reverse curves of the Semmering, has given up to the present every satisfaction. The new Semmering engines are fitted with Le Chatelier's counter-pressure steam brake, and with screw reversing gear. The Semmering is situated in the Styrian Alps, and is traversed by the railway connecting Vienna with Trieste, on the Adriatic Sea. The mountain section of the line is 26 miles in length, the average rise being 1 in 47, and the maximum inclination 1 in 40; the smallest curves are of a minimum radius of 9 chains, but this limit is not attained on the steepest gradients. In 1868 the total cost of "traction" on the Semmering was 1s. 9½d. per train mile, *vide* "Mémoires et compte rendu des travaux de la Société des Ingénieurs Civils, 2e trimestre, page 300."

2. The Brenner line in the Tyrol, which was opened in 1867, unites the northern and southern sections of the Tyrolean line on the South-Austrian Rail-

ways, forming thus a very important connecting link between South-Eastern Germany and the railway system of the Alta Italia. The mountain railway over the Brenner Pass is 78 miles in length ; there are long gradients of 1 in 40, and frequent curves of 14 inches radius. The Brenner is worked similarly to the Semmering, but the cost of traction is somewhat higher, on account of the price of combustibles. On both lines various sorts of lignite are consumed ; in the Semmering engines two sorts of lignite are burnt—Leoben lignite, having 65 per cent., and Styrian lignite, having 57 per cent. of the calorific power of coke from Witkowitz, which latter is about equal to ordinary English coals. The price of a ton of fuel, and equivalent to the heating power of a ton of coke, averages on the main line of the South-Austrian 16s., and in the Tyrol 33s. 8d. sterling. In 1868 the consumption of fuel in a Semmering engine was 84½ lbs. per train mile, and 60½ lbs. in a Brenner engine, the corresponding train loads being on the average 125 tons and 100 tons (goods and passenger trains). The security with which this difficult line has been worked since its opening is attributed chiefly to the system of "double-traction" with a head and a tail engine, coupled with the employment of Le Chatelier's steam brake. On several occasions the use of this apparatus, combined with the ordinary brakes, has enabled the engine-drivers to pull up within a distance of 300 yards, the train descending on a gradient of 1 in 40 at a speed of ten miles per hour.

3. The Poretta inclines, so called after the town of Poretta, situated on the northern slopes of the Apennines, connect Bologna with Pistoia, from which latter point the line branches off to Pisa and Leghorn to the right, and to Florence to the left hand. The distance between Poretta and Pistoia is 26 miles, over continuous gradients of 1 in 40. The summit of the line is at Pracchia, 10 miles from Poretta, and immediately after leaving the station of Pracchia the long Apennine tunnel is passed. There are altogether 47 tunnels over the 26 miles of railway, and frequent curves of 15 chains radius. One of the longer tunnels presents actually the development of a screw ; on leaving this remarkable tunnel on the top, the entrance hole can be seen down the precipice almost perpendicularly beneath. The Poretta is now being worked by the ordinary six-wheel coupled goods engines of the company. These engines—after the pattern of the Paris-Lyons goods engines—are fitted with various exhaust gear, screw reversing arrangement, and Le Chatelier's brake. The reversing screw is of steel, 2 in. in diameter, $1\frac{3}{8}$ in. pitch, supported by a wrought-iron chair bolted on to the footplate ; the nut is of case-hardened iron, 5 in. long, and the whole arrangement is altogether a very neat and efficient one. The Le Chatelier apparatus is fixed close to the reversing gear, so that both can be worked together with great facility. In applying the counter-pressure steam brake, the link motion is first of all put on mid-gear, and the regulator kept closed ; the injection apparatus is then so regulated that a thin cloud of steam may be seen over the chimney top; the regulator is then fully thrown open, and the link motion gradually reversed from mid to back gear, according to the retarding power required. In the goods engines the injection takes place in the blast pipe, while in the mixed engines, working on the main line, the apparatus injects in the exhaust ports underneath the slide valves; in neither case, however, the steam valve of the apparatus is made much use of. The maximum hauling power of the Poretta engines is a train load of about 110 tons. The express is drawn by one engine, while in the case of the mixed and goods trains two engines are employed ; in the former case both engines are coupled together in front of the trains, the front end of the second engine being next the hind end of the first engine tender. The goods trains are "drawn" by one engine and "pushed" by another, but the type of engine is the same for all trains. I must not forget to mention that the section from Bologna and Pistoia is constructed and worked as a "single line," and that the inconveniences caused by the working of the engines through the narrow tunnels are very great, and at times even alarming. In making an ascent with a mixed train, and having selected the footplate of the second engine as my "observatory," I was practically convinced that the limit of respiration was nearly as well attained as was, in fact, the limit of adhesion.

Name of Railway.	Section of Line.	Maximum Inclination.	Minimum Radius of Curves on Steepest Gradients, in Chains.	Type of Engine.	Diameter of Cylinder in inches.	Stroke, in inches.	Diameter of Wheels, in inches.	Boiler pressure, in pounds.	Heating Surface in square feet. Firebox.	Tubes.	Total.	Working weight of Engine, in tons.	Weight of Tender at Starting, in tons.	Total weight at starting, in tons.	Adhesive weight, in tons.	Maximum Train Load excl. Engine in Summer, in tons.	Speed on Mounting Gradients, in miles per hour.
South-Austrian	Semmering	1 in 40	20	Eight wheels, coupled, with tender (modified Engerth)	18¾	24	42	140	75	1570	1645	46⅓	19⅓	66	46⅓	175	10
		1 in 40	20	Eight wheels, coupled, with tender, system, Hall	19 11–16	24	42½	135	102	1850	1952	47	20	67	47	175	11
	Brenner.	1 in 40	14	Eight wheels, coupled, with tender, system, Hall	19 11–16	24	42½	135	·102	1850	1952	47	20	67	47	150	11
Alta Italia	Poretta	1 in 40	15	Six wheels, coupled, with tender	17¾	25⅝	51⅓	120	80	1267	1347	34	20	54	34	110	12
	Giovi	1 in 28½	20	Four wheels, coupled, twin engine	14	22	41¾	105	150	1398	1548	54	..	54	54	120	11
		1 in 28½	20	Six wheels, coupled, twin engine	16	22	48	115	157	2005	2162	66	..	66	66	140	11
		1 in 28½	20	Eight wheels coupled, system, Beugniot	23⅝	24	47¼	135	102	1915	2017	51	18	69	51	120	11
Swiss Central	Hauenstein	1 in 37	18	Six wheels, coupled, system, Engerth	17⅛	24	45¼	105	68	1210	1278	36	14	50	36	93	15
		1 in 37	18	Six wheels coupled, tank engine	17⅛	24	45¼	120	74	936	1010	40	..	40	40	93	15

4. The Giovi gradient in the Apennines, although only 6¼ miles in length, presents, of all the preceding mountain railways, the greatest difficulties and the greatest obstacles to a regular working. The ascent of the mountain begins close to Genoa, till the station of Busalla is reached, from where the line falls off, over light gradients, to the town of Novi, 34 miles from Genoa. Like the Poretta, this section comprises an uninterrupted succession of gigantic works of construction. The Giovi gradient begins at Pontedecimo, 8¼ miles from Genoa, and rises at the mean rate of 1 in 38 up to Busalla. The various gradients on the Giovi being composed of a stretch of 1 in 50, then 1 in 36, then comes a very short stretch of 1 in 28¼, and finally, through a tunnel of 3,280 yards in length, 1 in 34¼. At Pontedecimo, where there is quite an array of mountain locomotives, are now stationed sixteen six-wheeled coupled twin engines, twelve four-wheel coupled twin engines, and ten Beugniot engines. The passenger trains are taken over the Giovi by a Beugniot engine, for the mixed train a twin engine is usually added in the rear of the train, and the goods trains are hauled by two twin engines, one working in front and the other behind the train. To illustrate the nature of daily working on this remarkable line, I will cite the experience with a mixed train on the 19th of November last. The train was composed of eight passenger carriages and of ten goods wagons, making a gross load of 164 tons. To haul this train from Pontedecimo to Busalla, not less than 105 tons of adhesive engine weight were taken into requisition, viz., a Beugniot engine, weighing 69 tons (51 tons adhesive) in working trim, and a 54 tons twin engine. Including engines, the total weight of the train was consequently 287 tons, and, "guessing" the total resistances at 80 lbs. per ton, the corresponding tractive power would be 10¼ tons, or one-tenth of the adhesive weight under the engine wheels. The weather was rather misty, but the rails seemed to be in a normal condition. The Beugniot engine, leading the train, slipped terribly, with the safety valves blowing off at 135 lbs. to the square inch; in fact, the engine could only be got to "bite" by an energetic application of the sand-box. The twin-engine in the rear of the train—and working, therefore, under

more favorable conditions—kept on pushing very steadily. The ascent was made in 37 min., or at a speed of 10 miles per hour. The Giovi and the Poretta are on the very extensive railway system of the Alta Italia, this company working now 1,640 miles of railway, embracing the lines of the Piedmont, Lombardy, Venetia, Emilia, Liguria, and the lines on the right-hand bank of the river Arno. The Alta Italia and the South-Austrian railways belong to a French company.

5. The Hauenstein line, on the Swiss Central Railway, traverses between Bale and Olten, a very picturesque mountain range, called the Jura Alps, which attain at the Weissenstein, near Soleure, a height of 4,000 ft. above the sea level. The distance between Bale and Olten is 24½ miles, worked in two sections, Bale-Sissach, rising at the rate of 1 in 100, and Sissach-Olten, having a maximum inclination of 1 in 37; shortly before reaching Olten, the great Hauenstein tunnel is passed on a gradient of 1 in 38. There are frequent curves of 18 chains radius. The passenger trains averaging 85 tons, are worked by a passenger engine between Bale and Sissach, and by a six-wheel coupled goods engine from Sissach to Olten; the mixed and goods trains of an average weight of 160 tons, are worked by two goods engines over this latter portion of the line. The goods engines employed are six-wheel coupled Engerth engines, and six-wheel coupled tank engines; their adhesive weight is 36 tons and 40 tons respectively, and their maximum hauling power in good weather about 93 tons each, over the most difficult sections of the line. The ruling coefficient of adhesion on the Hauenstein is about ⅛, this being limited by the damp tunnel near Olten.

The foregoing notes concerning the service of traction on the mountain sections of the South Austrian, the Alta Italia, and the Swiss Central railways, are recapitulated in the annexed table.

MACHINE BEARINGS.

From "The American Artisan."

The great bugbear in machinery is friction. It is this that involves expense for lubricants, that causes the ultimate wearing out of the machine by the gradual destruction of its working surfaces, and that lays a constant tax in the shape of driving power not utilized in productive work. Although friction is by no means confined to the journals of mechanism, it is with these that its detrimental results are the most evident, and the means of alleviating it the most easily applied. Such alleviation is provided through the agencies of proper construction of the bearing and journal, the use of some interposed material offering less obstruction to the moving contact than is afforded by the surfaces themselves; and a suitable velocity of the journal as compared with that of the parts driven thereby—this last, of course, having more special application to lines of shafting.

As to the first of the above-mentioned essentials—the construction of the bearings and journals—it is well known that the friction between two different metals, as, for example, iron upon brass, is much less than that of a single metal upon itself, for instance, iron upon iron, and hence the now universal use of the Babbitt, type, and gun metals for journals. Aside from this, the length of the bearing in proportion to its diameter has much to do with its economical results; Fairbairn having demonstrated that with wrought-iron the length of the bearing should be 1¾ of the diameter of the journal. Both the length and diameter, moreover, must bear some relation to the pressure. The authority above cited lays down the rule that in fly-wheel, and similar shafts the pressure on the journal should never exceed 180 lbs. to the sq. in. In this connection may also be noted a very important point having reference to the resisting power of journals to tension and strain. As commonly made, with the shoulders turned down to a sharp angle, they lose one-fifth of their strength, which may, and always should be, avoided by making the corners, viewed from one side, rounded instead of sharp.

With regard to lubricating materials,

sperm oil has long been considered the best; but the lubricating material must, in a measure, be varied according to circumstances. With unguents, like lard or tallow mixed with oils, less useful results are obtained on metal than upon wood bearings. This is commonly ascribed to the adhesive and consequently resisting action of the somewhat viscous substance, and the effect of which has a certain ratio to the extent of the surface upon which it acts. Rennie's experiments with journals under pressures varying from 1 to 5 cwt. showed that with tallow and certain anti-attrition compounds the friction reached its minimum, while it rapidly increased with hog's lard and various kinds of oils. Under greater pressure, however, for instance, mill steps bearing a weight of 280 lbs. to the square inch, which it is difficult to keep properly lubricated, the finest and most limpid lubricating oils are recommended. Uniformity in the supply of the lubricant is also a matter of much consequence—too much involves waste and does only slight good, while too little, of course, does harm. It would be better than the present practice of intermittent oiling, if self-lubricating devices were universally provided upon journal-boxes, although it must be acknowledged that few or none of the scores of such apparatus that have been made, fully serve the useful purpose for which they were designed. As to the velocity of journals in motion, we need here notice only the conclusion of Fairbairn: that thereby will be a saving of from 30 to 60 per cent. in weight (and, of course, in friction) as compared with that involved in the slow motion once in vogue, and a large percentage of power formerly lost in the machinery of transmission will be utilized in the actual work in the machine to which the power is transmitted.

TELEGRAPHIC BATTERIES AND CONDUCTORS.*

Static or frictional electricity has long since been discarded as an agent in the electrical instrumentalities for communicating at a distance. All attempts hitherto to make it practicable have failed, and all the devices for that purpose, however ingenious, as most of them were, must be consigned to the category of failures. The principal form of electricity, which has been effective, either in the semaphore or in the telegraph, is dynamic electricity, usually generated by the chemical action of acids upon metals, or the decomposition of metallic salts. The earliest form of Voltaic battery, even the first column of Volta, is available to produce the actual result required, either of showing a signal, as in the semaphore, or making a record, as in the telegraph. The earliest form employed by Morse, in 1835, and with success so far as to show the practicability of recording, was the well-known Cruikshanks battery. Since this early period many modifications and substantial improvements in the battery have been made, and the constant batteries of Daniel, of Grove, and of Smee, in England, and of others on the European continent, have have given greater facility in operating the instruments both of the telegraph and semaphore. But the introduction of magneto-electricity, one of the grand results of the generic discovery of Oersted, and of the more recent discoveries of Faraday, has furnished the means of constructing a new generator of electricity, which takes its place intermediately between the frictional and the Voltaic, having less quantity than the Voltaic and less uncontrollable intensity than the frictional instruments. The Voltaic, however, has the quality of giving more readily a continuous current, and is therefore better adapted to recording in all the instruments using the Morse code.

FARMER'S THERMO-ELECTRIC BATTERY.

The batteries exhibited have little of originality. With one or two exceptions, they generally show unimportant modifications of those long known.

The thermo-electric battery of Farmer, of Boston, is one of novel construction, and deserving of special notice.

It consists of three rings of nine pairs each. A common rubber tube conveys ordinary street gas to a gas burner or gas

* From the Report of Prof. S. F. B. Morse, LL.D., U. S. Commissioner to the Paris Exposition.

stove under the centre of the battery. A deflector is placed at the top to keep the heat down in the centre. All that is required to put the battery in operation is to turn on the gas and light at the burner. The battery acquires its maximum activity in a few moments, when it works continuously and constantly as long as it receives heat.

These batteries are made of various sizes, weighing from a few pounds to half a ton. One of this larger class is now in operation, and is capable of depositing about one pound of copper per hour, at an expense of five or six pounds of coal in the same time.

The smaller batteries are more conveniently operated by gas or lamp. These latter are very convenient for medical use or for telegraph local batteries. The somewhat larger battery gives all the effects of a series of cells (of the acid batteries in common use).

These batteries are admirably suited to the wants of the exact experimenter, and render the most useful assistance in their investigations where an absolutely constant current is required, being capable of working for an indefinite period without a perceptible variation in the strength of current which they deliver. Their utility is very apparent to the electrotyper who desires a uniform current, and to the electro-gilder and silver-plater they are especially commended, because they require no acids, mercury, or liquids of any kind in their operation.

The saving which they effect in time, attention, waste, their cleanliness, the readiness with which they can be put into operation, the small expense of working them, and their durability, commend them to all.

Where an establishment is doing sufficient work to require the use of one of such size as can be operated by coal as a fuel, the economical production of electricity by their use is very obvious, five or six pounds of coal being capable of evolving as much electricity as one and a half pound of zinc, five or six pounds of sulphuric acid, and one ounce of mercury.

These batteries, like any series of cells, can be coupled to suit the work they have to perform. As compared with the acid batteries, these batteries have been worked with Boston gas as follows: 10 pairs equal to 1 Smee cell in power; 24 pairs equal to 1 Daniel cell in power; 44 pairs equal to 1 Grove cell in power. But in calculating for a battery to perform work for an indefinite period, an addition of 50 per cent. upon the above list is recommended, as the heating power of gas differs very materially in different places. Naphtha has been used with perfect success, and found very economical.

The principal objects kept in view in this invention are, first, to make a battery of sufficient power to be available for industrial uses; second, that it should be reasonably durable; third, that it should be convenient to use; fourth, that it should not be too costly.

With regard to the first object, one has been constructed and used which has deposited 12 lbs. of copper, from a sulphate of copper solution, in 24 hours, by the consumption of less than 110 lbs. of anthracite coal. Smaller ones have been constructed that are most conveniently operated by a gas flame, and which will evolve 50,000 ft.-lbs. of electricity by the consumption of 1 lb. of common coal gas.

These latter are made of various sizes, and capable of evolving from 20 to 300 ft.-lbs.. of electricity per minute. A common pint cup Grove cell will evolve 80 ft.-lbs. of electricity per minute. The current from this (gas-consuming) thermo battery is the most constant and uniform of any that I have ever used, and is admirably adapted to the requirements of exact research.

With regard to the second head, the durability of the thermo battery depends much on the temperature at which it is worked. At all temperatures there appears to be a gradual increase in the specific resistance of the alloys which enter into its composition, but the more slowly the lower the temperature of the heated junction. One of about 150 ft.-lbs. per minute power has been in nightly use for nearly a year. Its power has not been recently measured, but it is still in working order. Some have been in almost daily use by physicians for nearly two years.

Third. The gas-consuming batteries are as convenient as need be, requiring only to be attached by a flexible or other pipe to a gas burner. The large battery fired with coal needed attention every 3 or 4 hours.

Fourth. The thermo battery is much more costly than an acid battery of equivalent power, in the first instance; but the cost of daily maintenance is less. A thermo battery, equivalent in power to 4 or 5 Grove cells, costs about $90.

A thermo battery, to be heated by waste steam, could be operated at trifling cost, and would be very durable, but the amount required to do a given amount of work with only 120 deg. difference of temperature between the junctions, might be of inconvenient size and first cost.

In this battery the two elements used are, German silver for the negative pole, and an alloy of zinc and antimony for the positive pole. The proportions of the zinc and antimony used are, about 96 parts antimony and 53 parts zinc, as mixed in the melting pot. The pairs are arranged around a central source of heat; and the outer junctions are cooled by radiation and connection.

LECLANCHE'S BATTERY.

This batttery is much in use in the French telegraph administration. It consists of a prism of carbon for its positive pole, which is surrounded by a mixture of peroxide of manganese and carbon pulverized, filling the porous jar. This jar is put into the glass jar containing a solution of sal ammoniac; within the same glass jar and solution is a prism of amalgamated zinc, forming the negative pole. Its action is thus: On closing the circuit, the sal ammoniac is decomposed, the chlorine of the solution is absorbed by the zinc, the negative pole; while the hydrogen and the ammoniac pass to the positive pole, reducing the peroxide of manganese. According to the inventor's explanation, "the peroxide of manganese mixed with carbon being a good conductor of electricity, the system may be considered as a single fluid element, in which the positive pole is formed of an artificial metal having a great affinity for hydrogen."

MAGNETO-ELECTRIC BATTERY OF S. HJORTH.

This invention by S. Hjorth, of Copenhagen, relates to improvements introduced into the construction of magneto-electric batteries, with a view to obtaining by a slow motion of the armatures y required quantity or intensity of elecan fluid.

The improved battery may be constructed of different circles of bar magnets, set partly around and partly above each other, with corresponding intermediate armatures mounted on wooden or other suitable disks on a central shaft, made to rotate by suitable mechanism.

When quantity of the electric fluid is required, the currents are collected by rings, and from thence pass by conductors to a commutator mounted at the upper end of the central shaft. When intensity is desired, the conductors may be connected in one length according to circumstances.

The armatures are provided with false poles, the dimensions of which correspond with those of a certain number of magnets of similar polarity; say for instance 8 or 9 bars. The changes of polarity in the armatures at each revolution will consequently be equal to the number of these armatures multiplied by the respective series of magnets of similar polarity.

The power developed being in ratio with the number of changes of polarity produced at each revolution, an advantage may be obtained by the application of equal numbers of armatures and magnets. This arrangement is composed of 3 disks, each provided with 96 armatures, corresponding with the same number of magnetic bars, so that each revolution gives rise to changes of polarity equal to

$$96 \times 96 = 9,216 \times 3 = 27,648.$$

The armatures are coiled with wire internally and externally. The two intermediate circles of permanent magnets are fixed to brass rings.

The armature wheel or disk is formed of hard wood or other suitable material, and is provided with two rings, composed of vertical bars overlapping each other, in which the armatures are geared.

It is evident that the concentric series of magnets and armatures, as also the number of these elements, may be increased or decreased according to the effect to be produced. In all cases, the armature disks should be arranged "step-ways," so that when the armatures of the first series have completely passed between the magnets, those of the following series reach but half way, and those of the third series only commence to be drawn in between the magnets. The force of

attraction being thus added to the power applied to the central shaft, the motion of the latter is necessarily facilitated by increase in the power of the magnets.

The form, dimensions, and general details of construction of the apparatus above described may be varied according to its intended application.

LADD'S DYNAMO-ELECTRIC APPARATUS.

This apparatus is not in the catalogue, but was exhibited in the English department.

A French journalist thus enthusiastically speaks of it:

"In the judgment of all competent persons, the most astonishing object in the galleries of the Champ de Mars is the machine of Mr. Ladd, constructor of physical instruments, of London, exhibited under the name of Dynamo-Electric Apparatus. Very extraordinary in its principle, in its construction, and in its action, it is composed essentially of two plates of soft iron about 2 ft. long, 1 ft. wide, and 4 in. thick, kept at a distance of a few inches from each other. They are both of them attached by their ends to two kinds of cylindrical surfaces, also of soft iron, in the bosom or hollow of which turn two armatures of Siemens' cylinders, of soft iron, grooved upon their two faces and covered according to their length by insulated copper wire. An insulated copper wire sufficiently large surrounds also the two plates in compacted spirals perpendicular to their length, and going from one plate to the other, so as to form a closed circuit. The current pervades it through a commutator designed to maintain it always in the same direction. The second armature, on the contrary, is entirely out of the circuit of the first armature and of the plates of soft iron. It turns simply opposite the second poles of the plates, and becomes the seat of an induction current always in the same direction, which, conducted by the wires soldered to the two poles, goes to produce outside the effects of light, of heat, of motion, of affinity, or of chemical decomposition, as may be desired.

"It is perceived that in itself this whole mass of soft iron, of copper wires, without steel, without magnets, is absolutely inert. How can life and activity be given to it? By providing it with a small quantity of magnetism, by priming it magnetically. It is sufficient for this strictly to place properly the plates by putting them in the magnetic meridian, so that the terrestrial magnetism may communicate to it a slight magnetism. But it is better to make to pass once, and once for all, through the wire which surrounds the plates, the current from a Daniels', Smee's, or Bunsen's battery, which, after having made them temporarily electro-magnets, leaves them, the circuit being broken, with a little of residual magnetism, which magnetism for the future (and if they are not left too long to themselves) renders them always ready for action, or to create torrents of electricity of which they become the source. We have thus passed from absolute inertia to static or powerful activity. Motion completes all the rest. It is sufficient, in fact, to turn at the same time the two armatures, so that in returning constantly upon itself, the inductive current engendered at first by the residual magnetism incessantly increases the polarity or the activity of the plates, which have become powerful electro-magnets, and so that the second armature becomes the point of departure of an electric current of quantity and intensity proportional to the rapidity of rotation of the armatures, or to the force expended by the operator. With the machine exhibited, of which we have given the dimension so small, the exterior current is equivalent to that of 25 or 30 Bunsen elements.

"It supplies a Foucault regulator of medium size, and maintains at a white heat a platinum wire of more than a yard in length and half a millimetre in diameter. Here then is the immediate transformation, from the only condition, a small quantity of residual magnetism, by means of mechanical motion, first of power, next of electric effects, then luminous, calorific, and chemical, etc. Nothing in fact is more simple, more effective. Nothing also is more grand, more unexpected, more mysterious. Mr. Ladd has borrowed from Mr. Wyld his plates, leaving out the magneto-electrical apparatus, substituting for it simply the residual magnetism, and adding a second armature, which is the new element of his invention. He has taken from Messrs. Wheatstone and Siemens their return of the current upon itself, forcing it thus to increase itself, constantly multiplying it-

self, and like them rejecting the battery, for which there is no necessity."

If others do not go quite so far as this earnest French writer in designating the apparatus of Mr. Ladd as "the most astonishing object" in the whole Exposition, they will certainly agree with him in his admiration of the *effects* of this beautiful instrument, and in his designation of them as "grand, unexpected, and mysterious." Mr. Ladd is stated to have borrowed from Messrs. Wheatstone and Siemens their method of causing the current to return upon itself.

An account is given of this discovery from the pen of the discoverer, the eminent Dr. Werner Siemens, of Berlin, who seems to have observed this effect, and utilized it, apparently concurrently with Professor Wheatstone, but in reality a little before him, as will be seen by the following letter addressed to Professor Morse :

"BERLIN, *December* 30, 1867.

"Herewith I send you the translation of my communication to the Academy of Sciences in Berlin. I have had it done in London, for we are very weak in English here. As you see by the date of the communication, the publication took place about one and a half month sooner than my brother's and Mr. Wheatstone's speech in London. Already, in November of last year, my first machine was in working and made known to the scientific men here. Wheatstone added something new to it. Ladd has the merit of having shown a larger machine than that in operation in Paris. I had not enough machine power in the Prussian department, and on that account did not take a very large machine with two cylinders, like Ladd's. If you should visit Berlin on your return journey (which I hope), I can show you this machine, which gives a brilliant electric light and produces ten cubic centimetres of oxygen and hydrogen gas per second. I could also show you other interesting apparatus. A new mechanical tachygrapher for Morse writing, and an electric distance measurer. This would be especially useful to steamships, as with them we can measure the exact distance of steamers, light-houses, coasts, etc., while in motion."

"*On the conversion of mechanical effect into electric current without the employment of permanent magnets.*—When two parallel wires forming part of the circuit of a galvanic battery are approached to or separated from each other, a diminution or augmentation of the strength of current in the whole circuit is observed, according as the movement is in the direct or the inverse direction of the forces which the currents in two wires exercise reciprocally upon each other.

"The same phenomenon is observable still more remarkably when the poles of two electro-magnets, whose wires form parts of the same galvanic circuit, are made to approach or recede from each other. If the direction of the current in one of the wires is changed at the moment of their greatest or least distance, as is the case in all electro-dynamic rotating apparatus, a lasting diminution of the current occurs as soon as the apparatus is put into motion. This diminution of the current of the battery by opposite induction current it is which renders it impossible to employ galvanic electricity successfully as a motive for the production of mechanical effects. Suppose such a machine to be turned backward by some foreign force, it is evident that these induction currents must add themselves to that of the battery, which they proportionally strengthen; and since an increase of this circuit current is necessarily followed by an increase of magnetism in the soft-iron cores, and then again by a further corresponding increase of currents, and so on, the accumulation very soon reaches a point at which the galvanic battery may be removed from the circuit without occasioning any perceptible diminution in the resulting current. The moment the rotation is interrupted, however, the current ceases and the magnetism vanishes. Sufficient magnetism remains, nevertheless, in the iron to cause the process of accumulation to recommence from the moment that the rotation is renewed. It is only necessary, therefore, to magnetize the iron once by a galvanic current of short duration in order to render it forever afterwards capable of being recalled into action by simple rotation.

"The direction of the current depends upon the polarization of the residuary magnetism; and it can only be changed when, by means of a galvanic current, the residuary magnetism of the iron is changed.

"The effects here described take place

also with every electro-magnetic machine whose movements depend upon the attraction and repulsion of electro-magnets whose wires form a single circuit. Nevertheless, in order to provide apparatus especially for showing powerfully the phenomena of the dynamo element, a particular construction is found to give the best results. The wire of the stationary electro magnet must have a sufficient magnetic inertia, so that the strength of the attained magnetism does not diminish during the reversing of the current in the wire of the rotating armature. It is also essential that the armature should be so constructed that during its rotation the opposite polar faces of the electro-magnet should be always magnetically closed. These conditions are best fulfilled by the employment of the band form of armature proposed by me some years ago, and which has since then come very generally into use. The armature in question consists of a cylinder of soft iron rotating upon its axis. It carries an insulated wire wound in two deep longitudinal grooves, one in each side. The poles of a battery of permanent magnets, or, in this case, those of the stationary electro-magnet, are cut out so as to let the armature rotate with the least possible space between them.

"By means of a machine constructed upon this principle, if the proportions of the various component parts are justly determined and the commutator properly placed, and a sufficient velocity of rotation given to the barrel armature, a current may be produced in the wire which is so intense that it develops heat enough to burn the covering with which the wire is insulated. This accident, however, can be avoided, when the machine is required to be kept in constant action, by the introduction of resistances or by moderating the velocity of rotation.

"Magneto-electro inductors do not increase in power proportionally with an increase of dimensions, whereas with the machine in question the reverse is the case. The reason of this is that in permanent magnets the magnetism increases in a very small ratio to the weight of metal of which they are made, and that with a battery of permanent magnets it is impossible to concentrate their action upon a limited surface without their mutually diminishing their strength to a very material extent. On this account, steel magnets are not well adapted for employment in magnet inductors which are required to produce very strong currents. It is true that such machines have been made with permanent magnets, which have given an intense electric light, but, in order to attain this, they were required to be of colossal dimensions, and were correspondingly expensive. In addition to this, the magnets lost very soon the major part of their magnetism, and the machine therefore its force.

"Mr. Wyld, of Birmingham, has lately constructed a machine for the production of powerful magneto-electric currents, whose capability he has increased by the employment of two barrel inductors of my construction, as described above. In the larger of the two he has substituted an electro-magnet for the battery of permanent magnets, setting it in action by the current of the smaller one, and as the electro-magnet becomes more strongly magnetic than permanent magnets could, the resulting current is correspondingly stronger.

"It is easily seen that Wyld has, by this construction, considerably obviated the difficulties found in employing steel magnets. But independently of the inconvenience attending the use of two inductors, his apparatus has still the disadvantage that it is directly dependent upon the steel magnets of the first inductor for the efficiency of its operations."

SULPHATE OF MAGNESIA BATTERY.

A new battery is described by Mr. McGowan, general superintendent of telegraphs in Victoria, Australia, as producing an economy over the sulphate of copper battery, used for the local battery to work the register.

This form is known as the sulphate of magnesia battery, and has been patented. "The containing cell is of more than ordinarily large dimensions; the negative and positive elements are copper and zinc, cylindrical in form, and the exciting fluids are: 1, sulphate of magnesia, in the form of a nearly saturated solution ; 2, sulphate of copper in broken crystals. The former surrounding the metals in the containing vessel ; the latter in partial solution, admitted through a perforation at the extremity of a conical glass receiver, placed within the interior cylinder."

SUBMARINE TELEGRAPH CABLES.

In consequence of the success which has attended the use of submarine telegraph cables, and especially the great success of the Atlantic cable enterprise, the attention of the skilful has of late been turned to the importance of improving and perfecting them.

There were many electrical experiments made with submarine conductors for various scientific purposes previous to their application to telegraphy.

It is believed that the first submarine telegraph line was laid and operated in New York harbor by Morse, in October, 1842. Although destroyed early after its submersion, by the anchor of a vessel getting under way, it was not destroyed until the fact of its ability to transmit despatches was fully demonstrated. The gold medal of the American Institute was bestowed for this success.

Since that date the skill of European, especially of English, French, and Prussian savans, has succeeded not only in improving the construction of submarine cables, but in extending them in various directions from the United Kingdom across rivers, straits, and channels, and through seas, until the islands and continents of the eastern hemisphere are to a great extent telegraphically united, and the great enterprise of the day, the Atlantic telegraph, through the skill and perseverance and capital of English and Americans, has been the overcoming of the apparently insurmountable obstacle of an ocean deemed until recently unfathomable. It is unnecessary here more than to allude to this well-known enterprise, since the exhaustive history of it is familiar to all who have read the history of the Atlantic telegraph in the graphic pages of Doctor Russell and the Reverend Henry Field.

COMPOUND TELEGRAPH WIRE.

As directly connected with the improvement of submarine cables, attention is drawn to the "compound telegraph wire," the invention of Moses G. Farmer, Esq., of Boston, who exhibited the thermo-electric battery, already described.

Mr. Farmer, in a letter to Professor Morse, dated Boston, July 29, 1868, thus describes this valuable improvement, and the tests to which it has been subjected :

"I sent to you, a little time since, a pamphlet relating to our new compound telegraph wire, composed of a steel core and a copper covering, the whole coated with an alloy, principally tin, for preservative purposes. You will take in at a glance the numerous advantages of this wire.

"As has been most fully shown by Thomson's researches, and amply demonstrated by the working of the Atlantic cable, the speed at which a line can be worked is directly as its conductivity, and inversely as its electro-static capacity. The distance, also, which can be reached is directly as the conductivity, and as the degree of insulation. Anything, therefore, which improves the conductivity, or diminishes the static capacity, or increases the insulation, is a benefit.

"Let us look for a moment at the comparative conductivity, strength, and specific weight of iron, steel, and copper. I have carefully measured and recorded one or all of these elements for more than fifty samples in common use. I find upon an average that from $2\frac{3}{4}$ to 3 miles of common telegraph iron wire would break of its own weight if suspended vertically; about $1\frac{3}{4}$ miles of copper, and about $7\frac{1}{2}$ miles of the steel which we use. I copy my coefficients :

$$\left.\begin{array}{lr} \text{Steel} \ldots\ldots\ldots\ldots\ldots\ldots & 7.47 \\ \text{Galvanized iron} \ldots\ldots & 2.91 \\ \text{Copper} \ldots\ldots\ldots\ldots\ldots & 1.72 \end{array}\right\} \left(\frac{\mathrm{T}\,l}{w}\right)$$

"Now, for weight per mile, take the diameter of the wire in inches, and multiply its square by—

$$\left.\begin{array}{lr} \text{For steel} \ldots\ldots\ldots\ldots & 13373. \\ \text{Fir iron} \ldots\ldots\ldots\ldots & 13800. \\ \text{For copper} \ldots\ldots\ldots & 15400. \end{array}\right\} \left(\frac{w}{ld^2}\right)$$

"The result will be the weight per mile, 5,280 ft.

"Now, for conductivity, assume as unity a round wire of chemically pure copper, $\frac{1}{20}$ in. in diameter ; it would weigh $39\frac{1}{4}$ lbs. per mile. I will copy my latest coefficients, which, if multiplied by the weight per mile, will give the actual conductivity in terms of the unit above assumed, viz.:

$$\left(\frac{c\,l}{w}\right)$$

For steel..................	.00262.
For copper................	.02045.
For galvanized iron........	.00355.

"The coefficient for copper, .02045, is one for commercial copper, which I used in making up the tables in the pamphlet

referred to. We now use a copper, for which the proper coefficient is, .02301, or 90 per cent. of pure copper (which would be .02556).

"The resistance of 5,280 ft. of pure copper wire, weighing 39.11 lbs., would be about 21.3 B. A. units.

"Now, with the help of these coefficients, let us examine 2 or 3 wires. No. 8 iron wire weighs 375 lbs. per mile. (*Vide* Shaffner, L. Clark, M. G. Farmer.) Hence its tensile strength, or the weight which would break a short length of it, would be $T=2.9\times375=1087$ pounds, and its conductivity would be $C=.00355\times375=1.331$—Farmer's latest; ($C=1.298$, L. Clark). This refers to ordinary galvanized iron wire, at about 10 or $10\frac{1}{2}$ cents per pound, and not Washburn's best at 14 cents.

"Now, take 56 lbs. per mile of steel:

$$\text{Its } T = 7.47 \times 56 = 418.$$
$$\text{Its } C = .00262 \times 56 = 1467.$$

"Take, now, 56 lbs. of copper per mile, and we have:

$$\text{Its } T = 1.72 \times 56 = 96.$$
$$\text{Its } C = .02045 \times 56 = 1.145.$$
$$\text{Or its } C = .02301 \times 56 = 1.288.$$

"Now the combined strength of the two would be—

$$T \text{ steel} + T \text{ copper} = T \text{ compound.}$$
$$418 + 96 = 514 \text{ pounds.}$$

"And the combined conductivity would be—

$$C. \text{ steel} + C. \text{ copper} = C. \text{ compound.}$$
$$.146 + 1.145 = 1.291.$$

"Or, as we now make it—

$$.146 + 1.288 = 1.434.$$

"Thus we have a compound wire weighing 112 lbs. per mile, having a conductivity of from 1.291 to 1.434, according to the copper used, fully equal, if not superior, to that of average No. 8 galvanized iron wire (1.298 to 1.331), which compound wire will require $\frac{514}{112}=4.58$, or $4\frac{1}{2}$ miles to be suspended vertically to break of its own weight, being more than 50 per cent. stronger than iron wire in proportion to the weight which it has to sustain. Hence it can probably be put up with fewer poles per mile, thus increasing the degree of insulation.

"I will here insert two tables:

Galvanized iron wire.

Posts.	Sag.	Tl	C	T	$\frac{w}{l}$	$\frac{Tl}{T}$
38.............	1	144.3	1.136	928	320	.155
38.............	2	72.2	1.136	920	320	.077
38.............	3	48.1	1.136	928	320	.052

Compound wire.

Posts.	Sag.	Tl	C	T	$\frac{w}{l}$	$\frac{Tl}{T}$
23.............	1	140	1.331	514	112	.272
23.............	2	70	1.331	514	112	.136
23.............	3	47	1.331	514	112	.091

"So that with 23 posts per mile, instead of 38, the insulation would be 33—$23\div23=\frac{65}{100}=65$ per cent. better, and with a sag of 2 ft., the strain on the wire at the insulator would be only about $\frac{1}{7}$ of that required to break a short length of the wire; and with a sag of only 1 ft., the strain would be less than $\frac{1}{3}$ of its ultimate strength. The uniformity and homogeneity of the steel render it less likely to break from flaws (and the short experience which we have had with it shows this). The saving of cost per transportation is evident at a glance.

"Now let us look at a larger wire. Suppose 187 lbs. per mile of steel, and 188 lbs. per mile of copper equal 375 lbs. per mile (same weight as a No. 8 galvanized iron, which has a tensile strength of 1087), and a conductivity of 1.331 (at best average):

	$\frac{w}{l}$	T	C	$\frac{Tl}{w}$
Steel	187	1397	.490	7.47
Copper	188	329	4.324	1.72
Summary	375	1720	4.814	4.59

"Here we have an increase over No. 8 of $1720-1087\div1087=\frac{58}{100}$, or 58 per cent. in tensile strength, an increase of $4.814-1.331\div1.331=261$ per cent.; or, in other words, we could reach three and a half times as far with the compound wire as with the iron of equal weight per mile, while the insulation could be improved by the use of fewer poles per mile, this wire being nearly sixty per cent. the stronger."

Table showing the relative weight, strength, and conductivity of the compound and other wires.

	$\frac{w}{l}$	T	C	$\frac{C}{C fe.}$
Table No. 1.....	375	1091	1.331	1
Table No. 2:				
Steel........	187	1397	.490	..
Copper......	188	325	4.324	..
Compound..	375	1722	4.814	3.61
Table No. 3:				
Steel........	119	889	.311	..
Copper.....	119	205	2.737	..
Compound..	238	1094	3.048	2.29
Table No. 4:				
Steel.......	52	388	.136	..
Copper.....	52	89	1.196	..
Compound..	104	477	1.332	1
Table No. 5:				
Steel........	78	583	.204	..
Copper.....	297	511	6.831	..
Compound..	375	1094	7.035	528
Table No. 6:				
Steel........	357	2768	.935	..
Copper.....	18	31	.414	..
Compound..	375	2799	1.349	1
Table No. 7:				
Steel........	136	1016	.356	..
Copper.....	43	74	.989	..
Compound..	179	1090	1.345	1
Table No. 8:				
Steel.......	56	418	.147	..
Copper.....	56	96	1.288	..
Compound..	112	514	1.435	1.07

Explanation of Columns.—1st, $\left(\frac{w}{l}\right)$ weight per mile; 2d, (T) tensile strength; 3d, (C) conductivity; 4th, $\left(\frac{C}{C fe.}\right)$ conductivity compared with common No. 8 galvanized wire.

Table No. 1 contains the elements for the average of No. 8 galvanized iron telegraph wire; table No. 2, compound wire of equal weight; table No. 3, compound wire of equal tensile strength; table No. 4, compound wire of equal conductivity; table No. 5, compound wire of equal weight and tensile strength; table No. 6, compound wire of equal weight and conductivity; table No. 7, compound wire of equal tensile strength and conductivity; table No. 8, compound wire, or ordinary equivalent of No. 8 galvanized iron wire, such as costs ten to eleven cents per mile at present.

The improvement of Mr. Farmer in the construction of telegraph wire is considered of so much importance as to warrant the insertion here of a more detailed specification of its advantages; and in view of the obstacles encountered in the construction of lines in the Ottoman Empire, to which the energetic director of Turkish telegraph alludes in his letter to the United States Minister resident in Constantinople, inserted in Chapter VI. (obstacles occasioned by the accumulation of ice upon the wires in certain localities), we specially commend the fact that the compound wire seems specially adapted to obviate these difficulties:

"There is a growing tendency in this and other countries to employ larger wire for telegraph purposes, in order to obtain a greater conducting capacity.

"Notwithstanding the many disadvantages attending the use of large telegraph wire, No. 4 has been adopted on important lines and for long circuits, in England, Russia, and other countries, solely for its superior conductivity; and it is well understood by telegraphers in general, that for the rapid and successful operations of the circuits, much depends upon this element. Especially is this the case in wet weather and upon long lines.

"Under certain conditions of the lines, consequent upon wet weather, *superior conductivity* will accomplish that which increased battery power utterly fails to do, and repeaters at intermediate offices, with their necessary main batteries, accomplish but imperfectly and unsatisfactorily, as a general rule, and in many cases fail to do altogether.

"Pure copper wire, having a conducting capacity of nearly 7 times that of galvanized iron wire, has, of course, a great advantage in this respect for telegraph purposes. Its use, however, has been prevented in consequence of lack of sufficient strength to sustain itself.

"In the American compound telegraph wire this vital objection to the employment of copper alone for this purpose is obviated, and a conductivity and relative strength, superior to that of galvanized iron, are combined in a lighter wire.

"The composite parts of this wire are steel and copper, the steel forming the

core, and serving mainly for strength, while the copper serves more especially as a superior conductor.

"In regard to relative strength, it is well known that the breaks in ordinary galvanized telegraph wire, occasioned by accumulations of ice and snow, and from other causes, occur at weak points, or at imperfections which are caused by flaws existing in the iron before galvanizing, as well as from the effects of that process.

"We therefore claim that our compound wire, even with a relative strength no greater, theoretically, than that of a galvanized iron wire, will be much less liable to breakage from these causes, in consequence of the uniformity of strength in the steel core, while, in fact, the relative strength itself, of the compound wire, is very much the better of the two.

"Steel wires, of sizes varying from No. 12 to No. 16, stretched from pole to pole, across streams from one-quarter to three-quarters of a mile in width, in the United States, which have withstood the accumulations of ice and sleet for years, are good illustrations in this connection. One special instance may be cited of a No. 16 steel wire, between fourteen hundred and fifteen hundred feet in length, which has been in operation across the Kennebec River, in Maine, for the past eight years; and which, we are informed by the superintendent of the line, has parted twice only during that period—in each case having been untwisted at a joint by the great strain upon it caused by an immense accumulation of ice, the wire itself remaining intact.

"The advantages of increased conductivity and strength having been briefly set forth, there are other practical advantages to be gained in the use of the American compound telegraph wire, to which we would respectfully call the attention of contractors and telegraph companies.

"Large wire is used only because of its superior conductivity; and it is obvious that a light wire is preferable in handling and stringing, which can be done with less labor.

"Also, maintaining a superior conductivity and relative strength, the lightness of this wire will admit of an average of at least ten poles to the mile less than would be otherwise necessary.

"This reduction in the number of poles per mile will not only conduce to economy in construction, but it will effect a decrease of twenty-five per cent. or more in escape of the electric current.

"In stringing over the tops of buildings, stretches may be safely made double the length of those taken with the ordinary telegraph wire, and yet with less strain upon the insulators.

"Another point in its favor is the imperishable nature of copper, which, in this wire, is the exposed metal; the zinc coating of the galvanized iron being deteriorated near the sea, and from the effect of gases, etc., from chimneys, while copper will remain, under such conditions, unimpaired. In fact, under all circumstances, the durability of the compound wire is greatly superior to that of the galvanized wire in general use."

At the risk of some repetition the following observations upon conductors and insulation are extracted from a more recent publication by the American Compound Telegraph Wire Company, of which Mr. Moses G. Farmer is the consulting electrician.

"The method most commonly in use now, and always likely to be, for the construction of lines of telegraph, is to stretch a line of wire in the air from one pole to another, attaching it to the pole by the intervention of an insulator, connecting each end of the circuit with the ground. The reason we use an insulator is that we wish to transmit as much as possible of the current to the far end of the line before it enters the ground.

"Now, as a current of electricity divides itself into as many branches as there are paths open for it to travel in, and since the proportion of the whole current flowing in any particular path depends on the conductivity of that particular path, in comparison with the sum of the conductivities of all the paths, we wish to diminish the number and value of the paths of escape down the several posts which support the line.

"To maintain a current of electricity in a line of telegraph, we employ some form of galvanic battery. Those most generally used are the Grove nitric acid and the Daniels sulphate of copper battery. About five of the latter are equivalent to three of the former in ability to work a long line.

"Since, however good the insulator may be, some small portion of the current

escapes from the line, over it, down the post to the ground, it is manifest that if the line be long, the posts many, and the insulators very poor, a small portion only of the entering current may reach the far end of the line.

"The law which governs this may be thus enunciated. If the current upon the line near the battery be called the entering current, and that upon the distant end near where it enters the ground be called the arriving current, then the distance to which any stated fraction of the entering current will reach is proportioned directly to the square root of the conductivity of the wires, to the square root of the insulating power of the insulator, and inversely to the square root of the number of poles per mile used. It is customary, of late, to compare the resistance of different wires with one another, by referring them to the standard adopted by the British Association for the Advancement of Science.

"This unit is sometimes called an ohm, or an ohmad, a name given in honor of Dr. G. S. Ohm, who so fully developed the laws which govern the distribution and action of a galvanic current; an unit a million times larger than this, and called a megohm, is used to compare the resistance of insulators.

"A round wire of pure copper $\frac{1}{20}$ of an in. in diameter and about 250 ft. in length, nearly represents this unit of resistance; a nearer representation of it is a round wire 1 ft. in length, and $\frac{148}{1000}$ in. in diameter, made from an alloy composed of two parts of silver and one part of platinum.

Since a pure copper wire is from 6 to 8 times as good a conductor as an average iron wire of the same size, and since the distance to which we can work a line of telegraph depends, among other things, upon the conductivity of the line, it is plain that it would be desirable to use copper if it answered as well in other respects as it does for conductivity; and the first lines in this country were actually constructed of copper, but it was soon found that its ductility and inferior tenacity rendered it inapplicable to the purpose. So iron wires soon came to be substituted for copper, and size No. 9, weighing about 320 lbs. per mile, was selected, as it seemed to generally possess about the same conductivity as did the No. 16 copper wire, which had been hitherto used.

"Since 1847 iron wire has been almost wholly used in this country, until within the past year, when the American compound telegraph wire made its appearance. This wire is the result of almost numberless attempts which have been made to utilize the well-known conducting power of copper; and it is at last accomplished by uniting copper, the best conductor, with steel, the strongest known material; thus at once securing lightness and strength with great conductivity in the same wire, copper being 6 or 8 times as good a conductor as iron, and steel being twice or thrice as strong.

"The American compound telegraph wire has a core of carefully-selected and well-manipulated steel, which core is first tinned, and then has drawn upon it a strip or ribbon of the very best Lake Superior copper, which is selected with the greatest care.

"In the course of its manufacture it goes through a great number and variety of processes, such as annealing, tempering, drawing, etc., and the completed wire is finished by passing it through a bath of melted tin, by which the copper and steel are welded into and made one complete whole.

"The smaller sizes are generally drawn into lengths of 1,000 to 1,500 ft., and are put up in mile bundles, 3 or more pieces being carefully joined together at the factory.

"A wire of ordinary iron, weighing about 320 lbs. per mile, and known to the trade as No. 9, will offer from 17 to 22 units of resistance or ohms to the mile. A compound wire composed half of steel and half of copper, offering the same mileage resistance, will weigh only about 100 lbs. per mile; an iron wire of average quality, weighing 375 lbs. per mile, and known as No. 8, will offer the same mileage resistance as a compound wire of less than $\frac{1}{3}$ that weight.

"None is suffered to go out from the factory as first-class wire, in which the conductivity of the copper is less than 90 per cent. that of chemically pure copper.

"It is manifestly a great advantage to use a light wire, if it presents the required ability to sustain itself, since it produces less strain upon the insulators, which are always brittle, and requires

posts of less strength to sustain it. The cost of transportation is also less, as also is the cost of handling in stringing, etc.

"The compound wire possesses another advantage, based on the fact that steel, even at a low temper, possesses a great degree of elasticity, so much so that it can be stretched or elongated one two hundred and fiftieth part of its length without taking a permanent set; but will, upon removal of the strain, return to its original length; and it is a fact that when a tree falls upon a line of the compound wire and does not break it, when the tree is removed the wire returns nearly or quite to its original position, instead of remaining stretched as does an iron wire.

"From this cause a line of compound wire keeps up to its original height, and does not sag more and more year after year, as an iron wire does.

"In order to show clearly the advantages which the compound wire offers in the construction of lines of telegraph, it may be well to compare the relative conditions as to strength and ability to work lines built of iron wire, with equally efficient lines constructed with compound wire.

"A very common mode of construction has been to use No. 9 iron wire, weighing 320 lbs., and putting it up on 35 poles per mile, with glass insulators on wooden pins, which insulators, in a long-continued rain storm, would not offer more than two or three megohms of resistance. We will suppose one wire used, the posts to be 25 ft. above ground. If the wire be of very good quality it will offer 18 ohms per mile of resistance, and if it be soft it will generally break at a strain of about 1,000 lbs.; but there being always more or less of flaws in a mile of the wire, if it be put up very taut it will break a few times the first year. We will suppose the posts 150 ft apart, and the sag of the wire midway between the posts to be 9 in.; this would be called pulled up pretty straight. The strain on the wire near the insulator would be 250 lbs., or 25 per cent. of the ultimate strength of the iron; and it would be more than that, as the strength of a wire is that of its weakest cross-section, and there being occasional flaws, 250 lbs. would sometimes be as much as ⅓ of the real strength of the wire.

"With a mileage resistance of 18 ohms, and with 35 insulators per mile, which offers 3 megohms resistance each in a very rainy day, the fraction of the entering current which would reach the end of the line, 250 miles distant, would be about 5⅓ per cent. The apparent resistance of the line, measured from one end, would be only about 238 ohms, instead of 4,500, which it would be if the line were insulated to absolute perfection. Suppose now that ordinarily 30 Grove cups are used at one end only, the total electro-motive force of the 30 cups will be about 48 volts, and the internal resistance of the 30 cups should not exceed 12 ohms; then the total resistance of the circuit, with all the relays cut out, would be 238+12=250 ohms, and the strength of the entering current would be 192,000 of a megafarad, or 192,000 farads.

"This is from 10 to 15 times as much strength of current as is ordinarily required to work a relay; and, indeed, the 5⅓ per cent. of it, or 10,176 farads, is amply sufficient to work the relay at the distant end of the line.

"We will now suppose that we employ a compound wire weighing 200 lbs. per mile, 90 lbs. of this wire being steel, and 110 lbs. of it being copper—its breaking strain will be about 1,040 lbs.; ¼ of this will be 260 lbs., and if it be put up on 19 posts per mile, with a sag of 16 in. midway between the poles, the ratio of the span to the sag will be the same as in the former case. The tension on the wire will be the same fraction of its ultimate strength, as in the case of the iron wire on 35 poles per mile; and from its superior homogeneity it will be less likely to break.

"Now, on a line thus constructed, the conducting resistance being 7.72 ohms per mile, and there being only 19 insulators of 3 megohms each per mile, we shall find that 34 per cent. of the entering current arrives at the terminal station, 250 miles distant, instead of 5⅓, as with the No. 9 iron wire; and we shall find that 12 cups of Grove's battery will cause as strong a current to arrive at the distant end as did the 30 cups on the previous iron wire.

"Some of the best constructed lines in the United States use a wire of extra quality, weighing 380 pounds per mile, with as low a mileage resistance as 13 ohms.

"These lines are built on 38 to 40 posts per mile, with glass insulators that in a hard rain do not show more than 9 megohms resistance each.

"A line so constructed would be capable of transmitting 90 per cent. of the entering current to a terminal station 70 miles distant, and 10 per cent. of the current to a terminal station 484 miles distant.

"But if a compound wire, half of steel and half of copper, weighing 140 lbs. per mile, and having a mileage resistance of 12 ohms, be put on 12 posts instead of 38, with the same kind of insulators, we should find that 90 per cent. of the entering current could be transmitted over a line 131 miles long, and 10 per cent. over a line 750 miles in length.

"If, instead of the compound wire, weighing 140 lbs.—only about $\frac{3}{8}$ the weight per mile of the iron—we make it weigh the same, namely 308 lbs. per mile, its mileage resistance would be only $4\frac{5}{10}$ ohms; and if it be put up, as in the last example, we should find that 90 per cent. of the current would be received at a terminal station 213 miles distant, and similarly 10 per cent. at a station 1,225 miles away.

"It is clear that the principle involved in the foregoing examples, namely, transmitting an increased percentage of the current by means of superior conductivity, or insulation, or both, is applicable to the double transmission and other intricate systems, as well as to the working of long circuits, and general operations in humid weather.

"*Increased conductivity* becomes of special importance to those systems which strive for greatly increased rapidity of transmission, particularly on long lines, as *this feature alone* aids us to overcome the retardation due to lateral induction.

"Its special advantages are also manifest on lines which may be liable to contact with trees, as the percentage of a current which will pass beyond a given local fault will be greater as the conductivity of the wire is increased. In other words, the greater the conductivity of the wire the less the escape from it.

"We have thus endeavored briefly to set forth a few of the advantages which this wire offers to enterprising contractors and companies which desire to remove the odium that has hitherto been the standing reproach of American lines."

THE TEMPERATURE OF COAL MINES.

From "The Mining Journal."

A paper by Mr. Edward Hull, the well-known geologist, entitled "Observations on the Temperature of the Strata taken during the Sinking of Rose Bridge Colliery, Wigan," was read at the Royal Society last week. Mr. Hull stated that, in an elaborate paper by Mr. W. Hopkins, entitled "Experimental Researches on the Conductive Powers of various Substances," published in the Philosophical Transactions for 1857, an account is given of a series of experiments made under the general supervision of Mr. Hopkins, F. R. S., himself, and Mr. W. Fairbairn, F. R. S., during the sinking of the Astley Pit of Dukinfield Colliery, in Cheshire. At the time this paper was written the depth attained was only a little more than 1,400 ft., and the rate of increase between the depths of 700 ft. and 1,330 ft. was found to be 1 deg. Fahr. for about 65 ft. These observations were subsequently continued until the pits had attained their full depth of 717 yards from the surface. The last observation made was in the shale overlying the coal seam, known as the Black Mine, which it was the object of the proprietor, Mr. Astley, to reach, and the temperature was found to be 75 deg. Fahr. Assuming the "stratum of constant temperature," or, as it is also called by Humboldt, "the invariable stratum," to be that which was reached at 16.5 ft. with a temperature of 51 deg. Fahr., the total increase of temperature would amount to 24 deg. Fahr., giving as the rate of increase 1 deg. Fahr. for every 88,925 ft. This is much below the average rate of increase. During a part of the period above referred to (from 1854-6), another coal pit was being sunk at Wigan, which reached the depth of 600 yards, down to the celebrated Cannel Mine. At this pit similar observations on the temperature of the strata were made very carefully by the manager, Mr. Bryham, which were kindly communicated to myself for publication, and will be found in my work on the "Coal Field of Great

Britain." The ultimate temperature attained in this pit at the depth from the surface of 600 yards was found to be 72 deg. Fahr.; and assuming the invariable stratum to be the same as that at Dukinfield Colliery, the resulting rate of increase would be 1 deg. Fahr. for every 61.5 ft., which accords very closely with the result obtained by Prof. Phillips, F. R. S., at the Monkwearmouth Colliery.

Since the time above referred to, the proprietor of the Rose Bridge Colliery, Mr. J. Grant Morris, determined to carry down the shafts from the Cannel seam to the Arley seam of coal, which was known to lie more than 200 yards below it; and consequently in the spring of 1868 preparations were commenced for carrying out this project. In the incredibly short time of one year and two months the Arley coal was struck, and was found to be of good thickness and quality. The total depth reached was 808 yards, and the ultimate temperature in the coal itself was found to be 93½ deg. Fahr. The manager of the colliery, Mr. Bryham, sensible of the value of observations on the temperature of the strata at such unusual depths (this being probably the deepest colliery in the world, certainly in Britain), made a series of observations with as much care as the circumstances would admit, and has intrusted them to me for publication. The mode of taking the observations was as follows: On a favorable stratum, such as shale, or even coal, having been reached, a hole was drilled with water in the solid strata to a depth of 1 yard from the bottom of the pit. A thermometer was then inserted for the space of 30 min., the hole having been sealed and made airtight with clay. At the expiration of the half hour the thermometer was taken up and the reading noted. It might possibly be objected that the time allowed (30 min.) was sufficient for the embedding of the thermometer, and that the readings are liable to error from this cause. I feel sure, however, that if any error has arisen it is inappreciable, and does not in the least invalidate the general result. In fact, I am assured by Mr. Bryham that, from actual testing on several occasions, he found less than this time of 30 min. sufficient for the purpose required.

While the temperatures of the strata were being measured, observations were also carried on *pari passu* on those of the open pit during the descent. These are given in the table annexed. By a comparison of the results in the two columns, it will be observed that as the depth increased, the differences between the corresponding temperatures in the pit and the strata tended to augment; in other words, the temperature of the strata was found to augment more rapidly than that of the open pit. The effects of the high temperature and pressure on the strata at the depth of 2,425 ft. are, as I am informed by Mr. Bryham, making themselves felt, and cause an increase in the expense both of labor and timber for props. This colliery, in fact, will be in a position to put to the test our views and speculations on the effects of high temperature and pressure on mining operations. In order to obtain the average rate of increase of heat as shown by the experiments at Rose Bridge Colliery, we may assume, in the absence of direct observation, the position and temperature of the invariable stratum to be 50 ft. from the surface and 50 deg. Fahr., which is probably nearly the mean temperature of the place. With these data, the increase is 1 deg. Fahr. for every 54.57 ft., which approximates to that obtained by Prof. Phillips, at Monkwearmouth, of 1 deg. Fahr. for about every 60 ft. If, on the other hand, for the purpose of comparison, we adopt the measurements for the invariable stratum as obtained at Dukinfield, we find the rate of increase to be 1 deg. Fahr. for every 47.2 ft. as against 1 deg. Fahr. for every 83.2 ft. in the case of Dukinfield itself.

So great a discordance in the results is remarkable, and is not, in my opinion, attributable to inaccuracy of observation in making the experiments. On the other hand, I may venture to suggest that it is due, at least in some measure, to dissimilarity in the position and inclination of the strata in each case. These I now proceed to point out. Rose Bridge Colliery occupies a position in the centre of a gently sloping trough, where the beds are nearly horizontal; they are terminated both on the west and east by large parallel faults which throw up the strata on either side. The colliery is placed in what is known as "the deep belt." Dukinfield Colliery, on the other hand, is planted upon strata which are highly inclined. The beds of sandstone, shale, and coal rise and crop out to the eastward at angles

varying from 30 deg. to 35 deg. Now, I think we may assume that strata consisting of sandstone, shales, clays, and coal, alternating with each other, are capable of conducting heat more rapidly along the planes of bedding than across them, different kinds of rock having, as Mr. Hopkins' experiments show, different conducting powers. If this be so, we have an evident reason for the dissimilar results in the two cases before us. Assuming a constant supply of heat from the interior of the earth, it could only escape, in the case of Rose Bridge, across the planes of bedding, meeting in its progress upwards the resistance offered by strata of, in each case, varying conducting powers. On the other hand, in the case of Dukinfield, the internal heat could travel along the steeply inclined strata themselves, and ultimately escape along the outcrop of the beds. I merely offer this as a suggestion explanatory of the results before us, and may be allowed to add that the strata at Monkwearmouth Colliery, the thermometrical observations at which correspond so closely with those obtained at Rose Bridge, are also in a position not much removed from the horizontal, which is some evidence in corroboration of the views here offered.

Thermometrical Observations at Rose Bridge Colliery.

Date.	Depth in yards.	Strata.	Temperature in open pit.	Temperature in solid strata.
July, 1854	161	Blue shale	— ° F.	64.5° F.
August, 1854	188	Warrant earth	—	66
May, 1858	550	Blue shale	—	78
July, 1858	600	Warrant earth	—	80
May 18, 1868	630	Raven coal	73	83
July 24, 1868	665	Linn and wool	75	85
April 19, 1869	673	Yard coal mine	76	86
Nov. 18, 1868	700	Strong blue metal	76	87
Feb. 22, 1869	736	Strong blue metal	76	88½
March 12, 1869	748	Shale	77	89
April 17, 1869	762	Linn and wool, or shale	78	90.5
May 3, 1869	774	Strong shale	80	91.5
May 19, 1869	782	Blue metal	79	92
July 8, 1869	801	Strong blue shale	79	93
July 16, 1869	808	Coal (Arley mine)	79	93½

CONSTRUCTION OF THE WOLF ROCK LIGHT-HOUSE.*

From "The Builder."

The Wolf Rock was stated to be composed of a hard, dark, felspathic porphyry. Its highest part was 17 ft. above low water of spring tides, which had a rise of 19 ft. The surface was rugged, rendering a landing upon it difficult. The depth of the water close to the rock was twenty fathoms, excepting on the south-east side, where a shoal extended for a considerable distance. In the year 1860, the late Mr. Walker was instructed to furnish a design for, and an approximate estimate of, the cost of the work. These having been approved, the author, who was then completing the Smalls Lighthouse, was appointed to carry out the work as resident engineer. The form and dimensions of the tower differed but little from those of the Bishop, the Smalls, and the Hanois. Its exact height was 116 ft. 4¾ in., its diameter at the base was 41 ft. 8 in., and near the top, at the springing of the curve of the cavetto under the lantern gallery, the diameter was 17 ft. For a height of 39 ft. 4½ in. from the base the work was solid, with the exception of a space forming a tank for fresh water. At the level of the entrance door the walls were 7 ft. 9½ in. thick, whence they gradually decreased throughout the whole height of the shaft to 2 ft. 3 in. at the thinnest part near the

* From a paper read before the Institution of Civil Engineers, in London, by Mr. Jas. N. Douglass.

top. The shaft of the tower was a concave elliptic frustum, the generating curve of which had a major axis of 236 ft., and a minor axis of 40 ft. It contained 44,506 cubic feet of granite, weighing about 3,296¾ tons, and its centre of gravity was 36 ft. 2½ in. above the base. In consideration of the exposed position of the work, it was determined to dovetail each face stone vertically and horizontally, in accordance with the system suggested by the author's father, and first adopted at the Hanois Lighthouse. This method consisted in having a raised dovetailed band, 3 in. in height, on the top bed and one end joint of each stone. A corresponding dovetailed recess was cut in the bottom bed and end joint of the adjoining stones, with just sufficient clearance for the raised band to enter it freely in setting. From experiments made upon blocks of granite put together in this manner with Portland cement, it was found that the work was so homogeneous as to be as nearly as possible equal in strength to solid granite. In addition to increased strength, this system of dovetailing afforded great protection to both the horizontal and the vertical joints, against the wash of the sea when the work was first set. As an additional precaution, each stone of the first twenty courses was also secured by two bolts to the course below. The masonry, to the level of high water spring tides, was set in fresh Medina Roman cement, part of which was supplied from the Government Stores at Chatham, and part was manufactured by Messrs. Francis & Co., from whom the Portland cement was obtained for setting the work above high water. All the cement used in the work was mixed with an equal portion of clean, sharp, granitic sand, obtained from the stamps refuse of the Balleswidden Tin Mine, near Penzance. This sand was of excellent quality for such work, every grain in it being hard, angular, and rough. Salt water was used for mixing all the cement required for the landing platform and for the solid portion of the tower; above this, fresh water was used. The step ladders for ascending from floor to floor, and the partitions between the rooms and staircase, were of cast-iron, and precaution had been taken to limit the use of wood for the fittings as much as possible, in case of fire. The doors, windows, and storm shutters were of gun metal. The windows of the watch or service room, immediately under the lantern, were specially arranged for admitting air to the lantern and for regulating the ventilation in all ordinary weather. The supply of air was admitted by a valve at the upper part of the window, so as to pass above the head of the light-keeper on duty, and upwards through an iron grating surrounding the lantern floor.

The lantern was one of the cylindrical helically-framed type, designed by the author, and adopted by the Trinity House.

The total cost of the undertaking, including the lantern, the illuminating apparatus, cost of work-yard at Penzance, vessels, and all incidental expenses, might be taken at £62,726.

Bessemer Steel making in France.—The total production of Bessemer steel rails in France in the first six months of 1869 amounted to 19,755 tons, against 10,562 tons in the corresponding period of 1867; it is probable that the French production of this description of rails will show a still further advance in the second half of 1869, as large orders have been given out during the last 2 or 3 months by the great French railway companies. Among the more recent orders of steel rails we may mention one for 2,000 tons, given by the Orleans Railway Company to the Creusot works at £11 7s. 2d. per ton, and another for 3,000 tons, given by the Western of France Railway Company to the Terrenoire works, at £11 10s. 3d. per ton.

At the Liverpool Assizes on Saturday, a piano dealer and tuner of pianos, said to be earning £300 per annum, claimed damages for such injuries received in an excursion train on the London and North-Western Railway as incapacitated him for the pursuit of his calling. Mr. Justice Brett, in addressing the jury, said that if sufferers from railway accidents got annuities equal to their prospective earnings, it would be impossible for the companies to carry on their business. Both parties, he held, should share the consequences of an ordinary liability to accident, and bearing this fact in mind, as well as the fact that railway companies were compelled to carry passengers, the jury should assess damages accordingly. The award of the jury was £600.

THE PURITY OF CROTON WATER.

From "The Chemical News."

The water supplied to the citizens of New York, at the liberal rate of 65 gallons to each person daily, is collected by the various branches of the Croton river from an area of 338 square miles in Westchester, Putnam, and Dutchess counties. The character of this water-shed is a sufficient guarantee of the purity of the water. The surface of silicious gravel rests on hard Laurentian gneiss, and is open pasture or woodland, with few swamps. No factories line the streams, which are liable to contaminate the water with refuse chemicals, and no towns or large villages exist anywhere in the district to pollute the waters with sewage. A recent survey of the water-shed has indicated fifteen points at which dams can be erected for the creation of large storage reservoirs, whose joint capacity would be 67,000,000,000 gallons, or a supply, at the present rate of consumption, for 1,000 days. One of these dams, 650 feet long, is now in process of construction at Boyd's Corner, in Putnam county, 23 miles from the mouth of the aqueduct. When this dam is completed, it will flood an area of 303 acres, and the reservoir thus produced will contain 3,369,206,857 gallons, or a supply for 50 to 55 days of drouth.

An analysis of the Croton water recently made in the editor's laboratory gave the following results for one U. S. gallon of 231 cubic inches :

	GRAINS.
Soda	0.326
Potassa	0.097
Lime	0.988
Magnesia	0.524
Chlorine	0.243
Sulphuric acid	0.322
Silica	0.621
Alumina and oxide of iron	a trace
Carbonic acid (calculated)	2.604
Water in bicarbonates (calculated)	0.532
Organic and volatile matter	0.670
Total	6.927
Less oxygen equivalent to chlorine	0.054
	6.873 grs.

These acids and bases are probably combined in the water as follows :

	GRAINS.
Chloride of sodium	0.402
Sulphate of potassa	0.179
Sulphate of soda	0.260
Sulphate of lime	0.158
Bicarbonate of lime	2.670
Bicarbonate of magnesia	1.913
Silica	0.621
Alumina and oxide of iron	a trace
Organic matter	0.670
Total	6.873

On evaporating a gallon of this water a residue of only 4.78 grains is obtained, the bicarbonates of lime and magnesia being left as simple carbonates.

The following tabular statement shows how favorably the Croton compares with the waters supplied to other cities :

PURITY OF CITY WATERS.

Impurities contained in one wine gallon of 231 cubic inches expressed in grains.

City.	Source.	Inorganic Matter.	Organic and Volatile Matter.	Total Solids.
New York	Croton, 1869	4.11	0.67	4.78
" "	Well, 8th Av.	38.95	4.59	43.54
Brooklyn	Ridgewood, 1869	3.37	0.59	3.92
Jersey City	Passaic River	4.58	2.86	7.44
Trenton	Delaware River	2.93	0.55	3.48
Philadelphia	Schuylkill River	2.30	1.20	3.50
Boston	Cochituate Lake	2.40	0.71	3.11
Albany	Hydrant	8.47	2.31	10.78
Troy	Hydrant	6.09	1.34	7.43
Schenectady	Well, State St.	46.88	2.33	49.21
Utica	Hydrant	5.50	0.96	6.46
Syracuse	New Reservoir	12.13	1.80	13.93
Rochester	Genesee River	12.02	1.23	13.25
Cleveland	Lake Erie	4.74	1.53	6.27
Chicago	Lake Michigan	5.62	1.06	6.68
Dublin	Lough Vartry	1.77	1.34	3.11
London	Thames River	15.55	0.83	16.38
"	Well, Leadenhall St.	90.38	9.59	9.97
Paris	River Seine	7.83	1.00	8.83
Amsterdam	River Vecht	14.45	2.13	16.58
"	Well	64.55	4.38	68.93

The new field gun for India is to be a muzzle-loading 9-pounder bronze rifled gun, weighing 8 cwt., and Col. Maxwell, Royal Artillery, who read a paper on the subject on the 14th ult., stated that the 9th Brigade is about to be armed with the new weapon. The gun will be fitted with Sir J. Whitworth's elevating screw, and, with the carriage and the usual spare gear, etc., will weigh about 32 cwt.

PRACTICE WITH THE TRANSIT.

By W. G. Marcy.

The common series for sine and tangent are:

$$\text{sine } x = x - \frac{x^3}{6} + \frac{x^5}{120} - \text{etc.}$$

$$\tan. x = x + \frac{x^3}{3} + \frac{2x^5}{15} + \text{etc.}$$

or, for small arcs:

$$\text{sine } x = x - \frac{x^3}{6} \text{ nearly;}$$

and $$\tan. x = x + \frac{x^3}{3} \quad \text{"}$$

Hence the differences, respectively, between the sine and arc, and between the tangent and arc, are $\frac{1}{6}$th of the cube of the arc and $\frac{1}{3}$d of the cube of the arc, nearly.

The higher terms of the series show that this applies more accurately to the sine than the tangent. The differences for 10 deg. are, respectively, .00088 and .00180. The differences for 20 deg., divided by 8, give .00088 and .00186.

In *one degree* curves, in which radius = 5730 feet, the formula

$$.0101 \times \left(\frac{\text{no. deg.}}{2}\right)^3$$

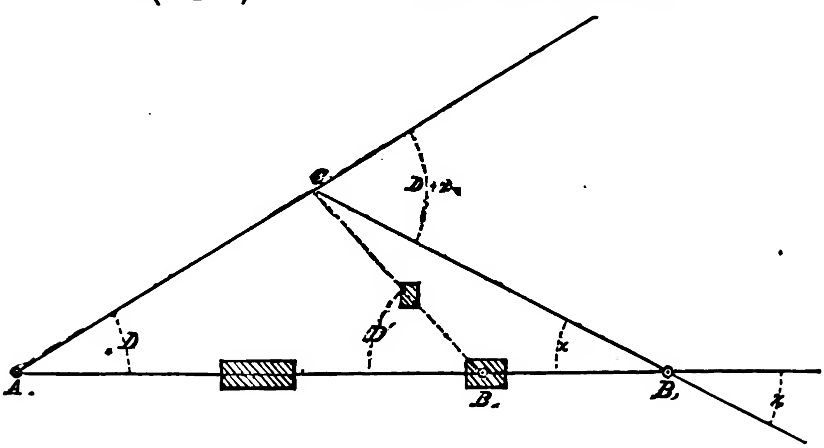
will express the difference between the arc and chord of 40 deg. within 0.1; and

$$.01047 \times \left(\frac{\text{no. deg.}}{2}\right)^3$$

will give the difference between the arc and tangent for 36 deg. within the same limits of error.

This is more accurate than ordinary chaining. These differences for equal angles in other curves being inversely as the "degree of curve," we may, in a majority of cases, determine the commencing and terminating points of a curve (marked *P C* and *P I* in the diagrams), independent of the field-book, and often more expeditiously than by use of the regular tables.

The difference between arc and sine 10 deg. being .00088, it follows that when sine 10 deg. is one of two factors, and the other not over 100, the product will be true to 0.1 if we use the arc; and for angles less than 5 deg. the product will be true to the same limit when the other factor is not over 800.



This consideration will so simplify as to make practicable several devices for expediting operations where trees, creeks, or other similar obstacles obstruct the progress of the survey.

As an example of this application of the formula, suppose an offset to be made from a tangent without making the isosceles triangle. (See Fig.)

Having made the usual offset to *C*, it is impossible to make *B*, it being inaccessible or surrounded by obstacles. Select $C B'$, so that

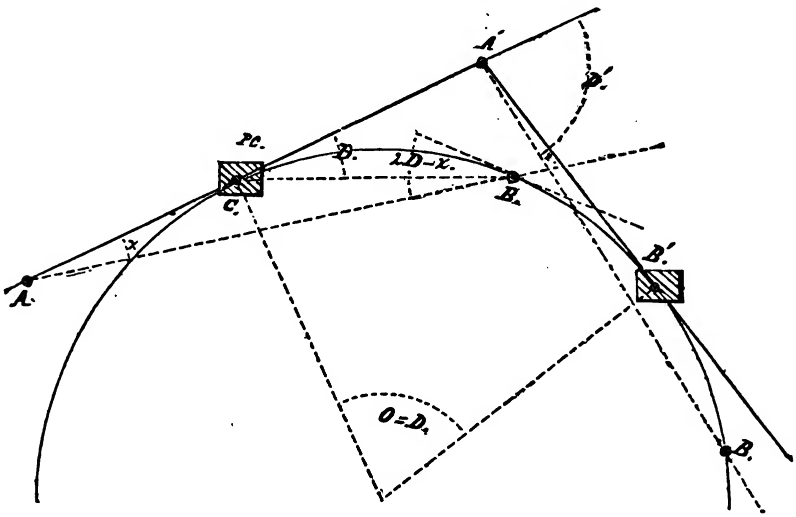
$$x = \frac{A C \times D}{C B'}$$

can be readily expressed. The deflection $D + x$ determines B', which can generally be made in time for the flag-pole at that station.

In passing small obstacles, D and x can

be made so small as to neglect the difference between $A\ C\ B'$ and $A\ B'$; or D may be a multiple of 1 deg., the difference for every 100 feet being as the square of $\frac{7}{4}$, $\frac{7}{2}$, 7, etc., divided by 200—these numbers corresponding to the offsets of 1 deg., 2 deg., 4 deg., etc., for every 100 feet.

To lay out a curve when the first tangent-point, $P\ C$, is inaccessible or surrounded by obstacles:

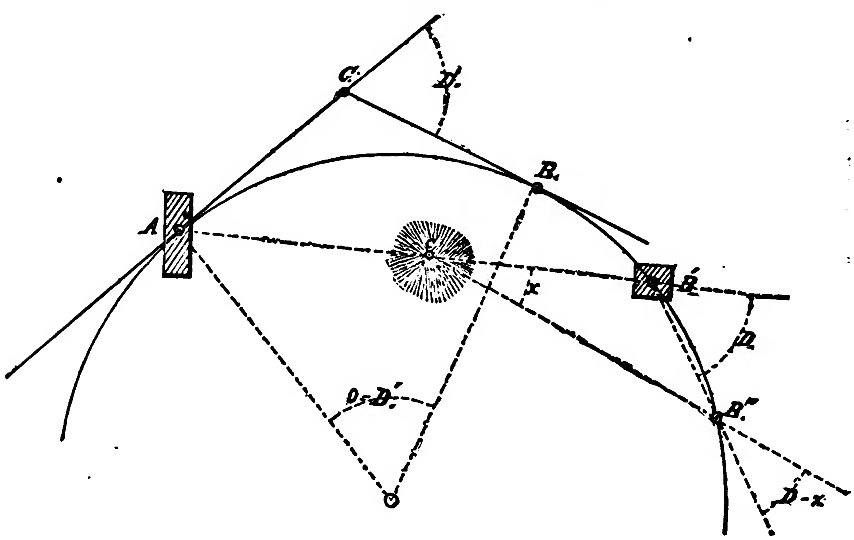


Setting the transit upon the tangent at A, select $C\ B$, so that

$$x = \frac{C\ B_{\circ} \times D}{A\ B}$$

can be easily expressed, the triangle being isosceles if convenient. If necessary more than one point may be determined from A, and, conversely, points of the tangent may be determined from B.

If the obstructions are too large, produce the tangent to A', making $A'\ C = A'\ B'$; D' corresponding to the centre angle $C\ O\ B'$. Should B' be inaccessible, proceed as originally from A.

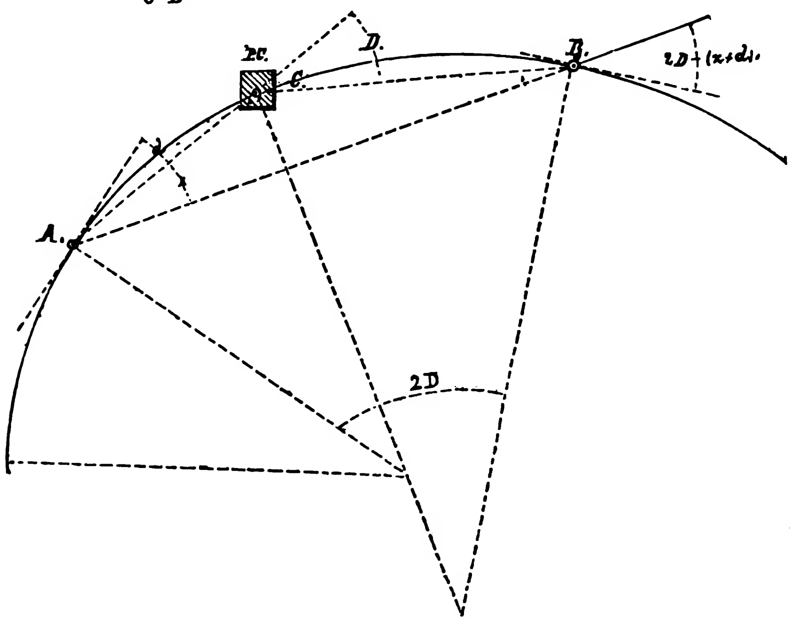


Small objects may be passed on a curve, either by removing two equal tangents, $A\ C$, $C\ B$, or a chord, $A\ B'$.

If obstacles occur at B', not seen at A, select $B' B''$, so that

$$x = \frac{B' B'' \times D}{C' B''}$$

can readily be expressed in degrees and minutes, D is the deflection from A to B''.



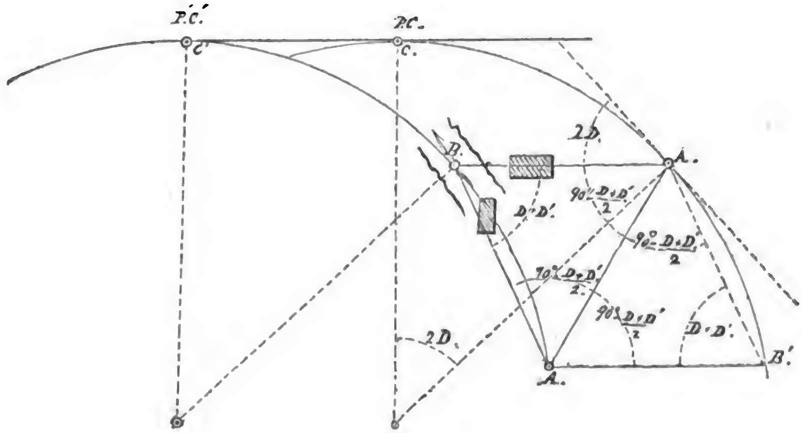
To lay out a compound curve without setting transit at $P\,C$:

The instrument being at A, make the deflection to C; then select $C\,B$, so that

$$x = \frac{C B \times D}{A B}$$

can be readily found. D is the deflection from A to B.

If C is inaccessible to the chain, measurements may be taken on the curve. This method applies also to reversed curves.



To offset from a curve whose origin is C to a curve of same radius whose origin is C':

From (A) any point of the given curve run $A\,B$ parallel and equal to $C\,C'$. If B is accessible to the chain only, construct the isosceles triangle $A\,B\,A'$. The angle D' in the diagram is the deflection from C' to A'.

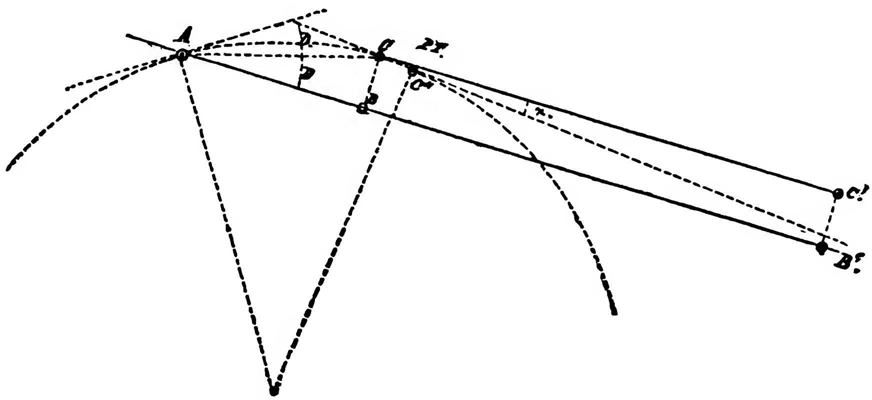
If B is not accessible, describe the isosceles triangle $A\,B'\,A'$.

It will be observed that the point A on

the first curve corresponds to B on the second.

Nothing is limited in this problem but the length of the chord $A' B$.

To change $P I$ to $P' I'$, not setting up at $P' I'$, when it is inaccessible to the instrument or chain, or there are obstructions to producing the tangent:



The instrument remaining at $P I$, we form an isosceles triangle; the distance $P I$ to $P' I'$ being one side, the other determines B on the tangent to $P' I'$. Deflection to B is twice the deflection to $P' I'$ in returning on the curve; but one-half in advancing. $P I$ is the vertex of the isosceles triangle in the former case; $P' I'$ in the latter.

If not convenient, the triangle may be scalene.

In these operations the angle and course is rigidly preserved. It is evident that in running trial lines, a wide departure from the limit (10 deg. $\times$ 100) would be both economical in time and satisfactory in results.

To terminate a curve that shall pass its tangent near a distant point B', $B B'$ or $C B'$ being estimated by the eye:

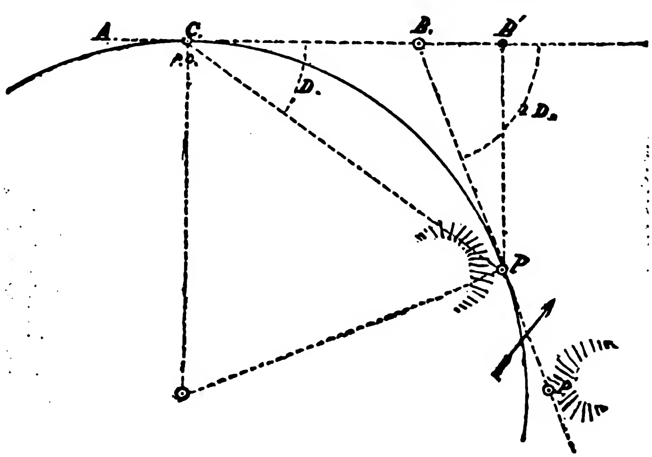
Denote by n the number of stations to make the tangent $C C'$ parallel to $A B$, n equalling 2 D divided by the degree of curvature.

Let y equal the number of extra stations to C'', $C B'$ or $B B'$ being expressed in chains of 100 feet.

We have $B C = n^2 \times \frac{7}{8} \times$ deg. of curve, nearly, $= \chi \times B B' \times \frac{1}{4} = y \times$ deg. of curve $\times B B' \times \frac{1}{4}$, nearly. Hence

$$y = \frac{n^2}{2 B B'}$$

Two approximations will often make a



closing line. The above value of y will be found to be convenient.

It is required to make the point P with a maximum deflection, 2 D, to avoid P',

passing with a given curve from the tangent $A\ C\ B$. $P\ C$ is the chord of the curve, and $C\ B = B\ P$ the tangents. If it is possible to make $2\ D$ without a continuous curve from P to C, we may run from $P\ B$, commencing at P, and come inside $A\ C\ B$, proving a greater deflection than $2\ D$ possible with a continuous curve.

Hence a continuous curve $C\ P$ makes $2\ D$ a maximum.

Let $P\ C = c$, $P\ B' = d$, $P\ B$ or $B\ C = p$, and radius of the curve $= R$.

We have p sine $2\ D = R$ tan. D sine $2\ D = d$; hence

$$2\ R \frac{\text{sine}\ D}{\text{cos.}\ D} \text{sine}\ D \text{ cos.}\ D = d;$$

$$\text{sine}\ D = \frac{d}{2\ R};$$

therefore $$C = \sqrt{2\ d\ R},$$

and $$R = \frac{C^2}{2\ d},$$

which determines R for any chord.

$C\ B'$ can be found from D and R.

THE HUDSON RIVER SUSPENSION BRIDGE.

From "The Iron Age."

One of the most important engineering enterprises projected in the vicinity of New York is the proposed suspension bridge over the Hudson River, the construction of which was authorized by the recent act of the Legislature incorporating the Hudson and Highland Suspension Bridge Company. This structure will extend across the Hudson River from Fort Clinton, on the west side, to Anthony's Nose, on the east, with one clear span of 1,600 feet, at an elevation of 155 feet above high-water mark. The plans of the company's engineers are not yet fully matured, but enough of the principal features of the work are already known to give a very clear idea of the extent and character of the proposed work. The total length of the bridge, including approaches, will be about 2,500 feet. The entire structure will be composed of steel combination truss and cable work, of great strength and graceful appearance. There will be four systems of twenty cables deeply rooted in the rock and abutments of the towers on either side of the river. Each cable will be about 14 in. in diameter, interlaced and secured by innumerable smaller cables, and will contain altogether 371,165,750 ft., or 70,302 miles of steel wire. The estimated weight of the iron and steel in the bridge will be about 17,000 tons, and the total suspended weight 9,651 tons. For the towers and approaches, 59,084 sq. yds. of solid masonry will be required. It is believed that the bridge, when completed, will be able to sustain the aggregate weight of sixty locomotives, or more than six times the weight that can ever be crowded upon it at one time. The estimated cost of the work has not yet been announced, but if the plan adopted by the engineers is fully carried out by the company, it will be one of the most remarkable and costly structures of the kind in the country.

As a new link in the chain of railroad communication between the West and the seaboard, the importance of this work is at once apparent. It is said that negotiations are now progressing towards the consolidation of several important roads in this enterprise, among which are the Hudson River, the Boston, Hartford and Erie, the New York, Oswego and Midland, the Delaware and Lackawanna, the Harlem, the Danbury and Norwalk, the New York and New Haven, Hartford, Springfield, Connecticut Valley and others, with their branches and tributaries. Among other benefits, it will reduce the cost of transportation on millions of tons of coal annually, from the Pennsylvania coal fields to all points east of the Hudson River, and on other freights will be saved the expense of transportation over the ferries at this point, which, including the cost of handling and transhipment, is about as great as the cost of moving it by rail from Philadelphia to Jersey City, or from this city to New Haven. The completion of this structure will concentrate the converging lines of railroad at a convenient point on the upper part of th island suitable for the location of a general freight depot, and will enable the principal roads of the Eastern States to make through connections with the West, without depending on the ferries, which are both inconvenient and costly. Steps

should be taken at once to supplement this important movement by the construction of a system of tunnel railroads through the city, for the distribution, at convenient points along our river fronts, of the freight and merchandise brought here for transhipment. This is an important and needed improvement, and its completion would contribute largely to the commercial prosperity of New York. It is announced that work on the bridge will be begun during the coming summer months, and that every effort will be made to insure its completion before the close of another year. This gives the question of tunnel railroads a present importance, and it is to be hoped that, before many months, our enterprising and public-spirited capitalists will have undertaken the work of providing better and cheaper facilities for the distribution of freight and merchandise throughout the city than are now enjoyed by the business community.

PERKINS'S COMPOUND MARINE ENGINE.

From the columns of late English papers we extract the following account of a trial trip of the Filga, a screw tug fitted with compound engines. "The Engineer" says :

"Two generations have all but passed away since Jacob Perkins preached the gospel of high-pressure steam—high-pressure above and beyond any high-pressure with which modern engineers have to do. We think it something to boast of, that the engines of the North London Railway use steam of 160 lbs. pressure ; but Jacob Perkins proposed to use steam of 1,000 lbs., and actually did use it under certain circumstances. The great body of mechanical engineers labor under the impression that Jacob Perkins's ideas died with him. No notion could be more erroneous. His ideas live with his grandson, and we saw them in practical application on Wednesday last, on board the steam-tug Filga, the property of Mr. Henwood. On board this boat, we confess that we stood for the first time over a marine boiler carrying 200 lbs. of steam. Time and space alike forbid us to enter into details. It must suffice to say that the boiler consists of a great number of wrought-iron tubes, about 3 in. diameter outside, and varying in length from 12 ft. to 10 ft., within which the water is contained and round which the heat plays. The engines of the Filga are illustrated, as far as general arrangement is concerned, in the annexed engraving. They consist of four cylinders, arranged steam-hammer fashion. The two upper cylinders are high-pressure 15 in. in diameter. The low-pressure cylinders are immediately beneath them. They are 32 in. diameter, the stroke of both being only 1 ft. The valves are all of the double-beat Cornish type, raised from their seats by spindles driven by eccentrics, but dropped by the pressure of the steam acting on the plus area of one valve. The surface condensers are of a peculiar construction, of which we shall have more to say. The circulating water is driven through it by a pump worked by an eccentric on the screw shaft.

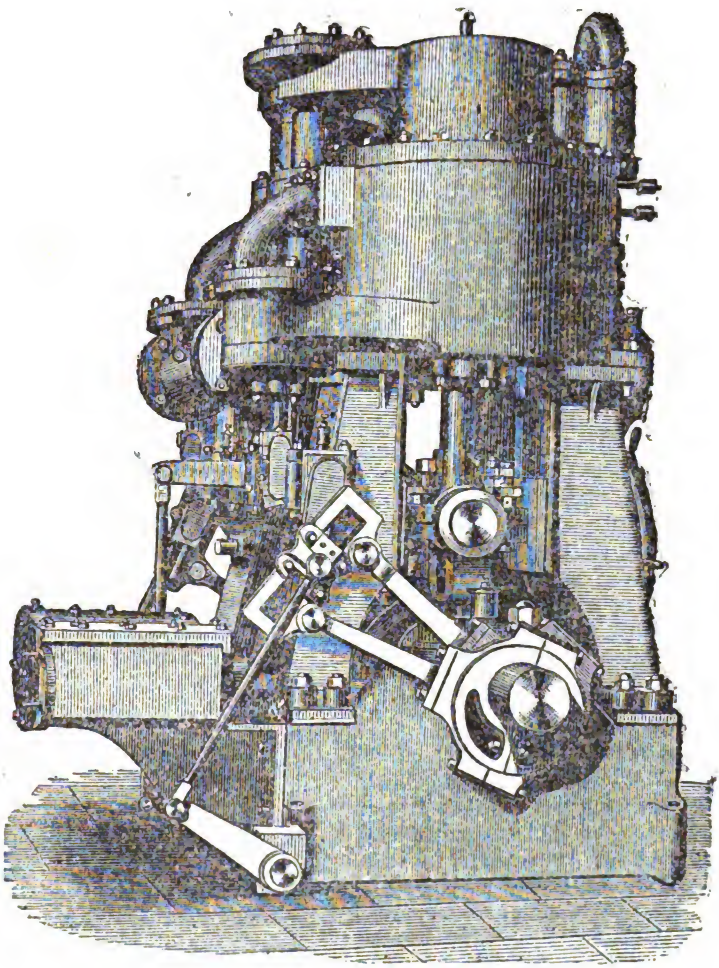
"The Filga is of the ordinary Thames screw-tug type, and it is doubtful if engines of any other form of 80-horse power nominal could have been got into her. She is 70 ft. long, 14 ft. beam, and draws 10 ft. She has a three-bladed common propeller 9 ft. 6 in. diameter, and 12 ft. 6 in. pitch. The boiler has not less than 2,200 square feet of heating surface, the grate surface being but 30 ft. The estimated consumption is a little under 2 lbs. of coal per horse per hour, but the actual consumption appears to be much less. On this point we shall have something more to say.

"The engine illustrated in the annexed engraving is almost precisely the same as that of the Filga, the only difference being that the cold water circulating pump is arranged vertically outside the engine frame instead of horizontally, as shown at the left of the cut.

"The Filga left Blackwall on Wednesday for a run down the river. The trip was in no sense a trial trip. It was simply intended to prove to a select body of engineers that it was possible to work 180 lbs. steam at sea ; and so far it was completely successful. Steam was easily maintained throughout the trip at 150 lbs. to 190 lbs. How such pressures are dealt

with we must explain at another time. No trace of steam was to be seen about engine or boiler, because the joints are absolutely steam-tight.

"The tide was strong against the little vessel on her run down, yet, on the measured mile in the Lower Hope, she attained a speed of 8.33 knots, with nearly 1½ knots of tide against her. This was not a trial run, and no special precautions were taken to secure a good result; but there is no doubt that the result was very good indeed, considering the size of the boat. The general particulars of the run may be thus summed up: The Filga left Blackwall at 12.30, passed North Woolwich Railway pier at 12.55, and Erith at 1.47 P.M. Gravesend was reached at 2.48, Thames Haven at 3.38, and the run back was made at such a pace that Blackwall



was reached at 6.40. Throughout, the working of the engines was most satisfactory. They are of enormous strength, and deserve, from their peculiarities, a separate article to themselves; and the same may be said of the boilers. We shall return, in an early impression, to the consideration of the work now being done by Messrs. Perkins."

The account given by "Engineering" of the same engines and their performance is as follows:

"On Wednesday last a very successful run was made with the screw steam tug Filga, which has just been fitted with one of Messrs. A. M. Perkins and Sons' marine engines, with safety boiler and surface condenser. These engines are on the

compound principle, steam-jacketed, and are of a peculiar yet simple construction, and occupy an exceedingly small space in proportion to the power they develop. The engines of the Filga are fitted with overhead single-acting cylinders, two being 32 in. in diameter, over each of which is another cylinder of 15 in. diameter. In these cylinders work double pistons having a 12-in. stroke, the same rod carrying both pistons. The steam is admitted over the upper and smaller piston, which performs the down-stroke, the steam passing thence to the underside of the lower piston, which makes the up-stroke. Surface condensers of special construction are used, by which means all the steam from the engine is condensed at atmospheric pressure, and the water returned to the boiler at a temperature of 212 deg., which practically means a gain of about $\frac{1}{4}$ in the fuel. Besides this, there are several other advantages attending this circulation of the water and its re-use in a distilled form. It is valuable in preventing deposits in the boiler, so that a fruitful source of explosion is absent, and a further economy of fuel is attained. The use of pure water also effects a saving in the wear and tear of pistons and valves, whilst it is found that the quantity of water required for Messrs. Perkins's condensers is less than that required for an ordinary high-pressure engine. These engines use steam at a pressure of 240 lbs. on the square inch, although we understand that pressures greatly in excess of this are used in the land engines at Messrs. Perkins's works in Seaford street, Regent square. The boilers consist of a number of wrought-iron tubes, $\frac{5}{8}$ in thick, and 3 in. in diameter. These are disposed in horizontal layers, and are connected by small vertical tubes, the flame passing between all the tubes. The boiler of the Filga is composed of thirty sections of eight rows, seven of which are above, and one below, the furnace bars. The tubes are proved at a pressure of 2,500 lbs. per square inch before use, and their construction being that of the separating principle, there is no danger to be apprehended from explosion. The safety-valve is loaded to 400 lbs. per square inch, the bursting pressure being about 20,000 lbs. per square inch. As already observed, these boilers depend greatly for their efficiency upon the purity of the water with which they are fed. The engines are therefore fitted with condensers, and the boilers with an automatic still for that purpose. This still is worked by means of a small pipe coiled in the still; when once the boiler has been filled, the still is only required to supply the waste.

"These engines, as a rule, are stated to consume under $1\frac{1}{2}$ lb. of coal per horse power; the returns of the consumption of coal on board the Filga are not to hand as we write, and we therefore defer a complete notice of the results of working until next week. The engines of the Filga are of 80-horse power, but will indicate 240-horse power. On the occasion of her recent trial trip, steam was kept at 180 lbs. pressure at the boiler, and 72 revolutions per minute of the screw shaft were steadily maintained almost from the time of starting to the time of return. Once or twice the revolutions reached 76, and once or twice they fell to 70, but the result of a number of intermittent observations gave 72 revolutions as the general rule. A fair average speed of 8.3 knots per hour was attained running down against tide. The Filga left Blackwall at 12.30, passed the Great Eastern Railway pier at North Woolwich at 12.55, reached the Crossness pumping station at 1 20, Erith pier at 1.45, Tilbury Fort at 2.46, and Thames Haven at 3.38, making a total run of 3 hours and 8 minutes. The vessel's head was then put round, and a rapid run was made up the river to the starting-point. The engines worked most satisfactorily, the general result being that they indicated nearly the same as double-acting engines with 41 in. cylinders and 36 in. stroke."

It was announced from Marseilles on the 13th ult. that the Europe steamer, 3,500 tons, 400-horse power, had arrived there from Bombay on the 12th ult., with 37 passengers. She left Marseilles on the 1st of January, and has, therefore, accomplished the two passages, *via* the Suez Canal, including discharging and reloading, in 70 days.

An improved form of electro-magnetic engine is announced in this city. We prefer not to endorse, just now, the brilliant promises of the inventor and owners.

THE USE OF LEAD PAINT.

From "The Building News."

The methods of manufacturing and preparing white lead for the painter's use are many and various, and would occupy a volume in description, and which would answer no purpose to enter into at length here, seeing that every information on the subject may be gained by consulting Muspratt's "Chemistry Applied to the Arts and Manufactures;" we shall therefore only now notice such facts as are useful to the house painter and decorator to know.

The white lead is, of course, a carbonate or oxide of lead—according to the method of its preparation. It is produced from sheet lead by two standard processes. One, the Dutch method, in which the reactions are effected by operating on metallic lead with acetic acid, and decomposing carbonaceous matters at a comparatively elevated temperature, and without any other moisture but steam; and the other, wherein the carbonate is thrown down from a solution of bassic acetate of lead, by transmitting carbonic acid through it. Large rectangular spaces are formed, enclosed by stout walls of brickwork or masonry, within which pots of acid containing coils of sheet lead are piled in stacks. These stacks are built up of layers of dung, acid pots, lead and boards, alternately. Eight layers of pots usually constitute the stack. Spaces are left at one end in every other layer, in order to create a thorough draught. Every stack contains about twelve tons of metal. A period, varying from five to six weeks, is allowed to convert the sheet lead into carbonate. The English method is a similar process to the above, but, instead of dung, spent tanner's bark is used, which, although slower in its operation, has the advantage of not darkening the lead by sulphate of hydrogen, which the dung evolves. With tan, nine or ten weeks are required to carbonate the lead; by the latter method the particles of lead are more minutely divided and finer; consequently, in use it covers better. It used to be the practice to grind the lead into an impalpable powder, and make it up into cakes for the market; but the process was so destructive to the lives of the workmen concerned that it has been virtually discarded, except for small quantities sold as dry white lead. The practice now is to compound it at once with the linseed oil. This is effected by an apparatus called a kneader, somewhat similar to that used in large bread-baking establishments. This is a cylinder in which a square iron bar, furnished with arms, is fixed longitudinally, and is turned by steam-power. All the materials—white lead and oil—to the extent of eight per cent. of the lead compound, are introduced by the doors, which are firmly closed. When the two are mixed the paste is withdrawn and ground to make it more homogeneous. The purest white leads are alone fitted for the painter's use in interior decoration. There are several of these in the market under the names of London white, Nottingham white, flake white, and the Belgian white—called Kreuzer white, and numerous others not necessary to our purpose to name, these being all white leads, but differently prepared. Pure white lead, when properly prepared, is the most valuable white we have for mixing with oil and making of paints; it is a pure white which will keep its color under all ordinary circumstances, and will mix with most colors without injuring them or being injured by them, and is capable of producing thousands of tints by admixture with other pigments; there is no other white with equal body when ground in oil, or that will cover as well; many substitutes have been tried, but none have as yet stood the test of practical use as compared with white lead. Its purity is not injured, or very little, by light, oxygen, or pure air, but is so, more or less, by sulphuretted hydrogen, damp and impure air. In using it as a white paint, it is most durable, keeps its color best, and is least liable to crack or peel if it is used with pure linseed oil alone, well mixed and passed through a fine straining sieve before it is used; it is well also to add a little black or blue to it in mixing, which will help to purify the white and resist the coloring effect of the oil.

In finishing white it is usual to add about one-third turpentine, as it assists its working in painting, but when it is used as flatting, *i.e.*, dead color without

gloss, we find in practice that the less oil is contained in the lead the more successful the flatting. We therefore beat the lead up in turpentine alone to a proper consistency; it is then left to stand for 10 or 12 hours, when the oil previously contained in the lead will rise to the surface and may be skimmed off; if the color is then too thick for working with, more pure turpentine may be added. We thus obtain the purest whites, and, by mixing, the most delicate tints of color it is possible to get from white lead in oil. We have hitherto been speaking of pure white lead alone, which may be known by the purity of its whiteness, its great density, solidity, and absence of spongy or granular appearance. Age improves its quality. It is supposed that in time a portion of the water it contains evaporates, and it thus solidifies. When white lead has been packed in cask for a long time, when opened the lead will be found to have sunk or diminished in bulk considerably, or solidified. New lead is distinguished by a softness and oily appearance, and consequent want of solidity; but if the lead is really good, the difference between old and new is not of very great importance for the generality of work. Unfortunately, white lead is subject to great adulteration, and this is invariably done in the manufactory. According to Muspratt, all the white lead which is manufactured into paint is more or less adulterated. Again, he says that some of our English white leads are pure, also the Kreuzer white, but the compounds sold under the names of Venetian white, Hamburg white, Dutch white, etc., are all adulterated to a very great extent.

The principal ingredient used for adulteration is sulphate of baryta, but whiting and other earths are used for that purpose, whereby its valuable properties are deteriorated and the public swindled.

Of three samples of white lead sent to M. Louret for analysis, the results were as follows: 1 grm. of No. 1 contained 0.695 of white lead, and 0.305 of sulphate of baryta; 1 grm. of No. 2 contained 0.340 of white lead, and 0.660 of sulphate of baryta; and 1 grm. of No. 3 contained 0.282 of white lead, and 0.718 of sulphate of baryta; yet hundreds of tons of these mixtures are sold annually as white lead at three or four shillings a cwt. less than he pure article. The adulteration may be detected by simply contrasting the pure white lead with such as is suspected to be adulterated. It is said that it may be detected by digesting the sample in dilute nitric acid, which dissolves the lead, but leaves the sulphate of baryta; however, it will be found that sulphate of bartya and whiting, when ground in oil, become discolored, in consequence of their want of body, and greater power of absorbing oil. Glaziers' putty is an example of this. When pure it is made of good whiting and linseed oil alone; the oil turns the whiting into a yellow stone color. It follows, as a matter of course, that if whiting or sulphate of baryta is mixed with white lead, the whiteness of the lead is impaired, its body weakened, and it will not cover as well. We have found in practice that two coats of pure white lead when mixed as paint will cover better or make a more solid ground than three coats of the slightly adulterated, or than four coats of the common or worst lead. Therefore it may be accepted as a fact proved by years of experience, that in its general usefulness, its powers of preserving and giving protection to wood or other materials, in producing good work, and, in an economical point of view, pure white lead, although the dearest in the market, is in all essentials the cheapest in practical use.

Flake white is another preparation of white lead in the form of scales or flakes, hence its name, and is an oxidized carbonate of lead, somewhat purer in color than the ordinary white lead, and is usually ground in poppy oil, and is principally sold by the artists' colormen, but is of great service to the decorative artist when a pure white is required; also in the finishing of imitation marbles in enamel work, *i. e.*, polished paint. It may also be used with advantage in varnish, being exceedingly fine in texture, and free from grit. Zinc white is also a useful white, and may be used either in oil or water. It is a pure oxide of zinc, and has one or two advantages over white lead, inasmuch as it is permanent under all circumstances, and comparatively innoxious both in its manufacture and use; in itself it is a bad dryer, but salts of zinc is mixed with it, which causes it to harden. There are four kinds—snow white, zinc white, stone grey, and grey oxide. The first two are of an unalterable white color; oxide of

zinc is also used in paper staining. Notwithstanding all its good qualities, zinc white is not a favorite pigment with the house painter, principally on account of its want of body. In practice this is found a great preventive to its general use; it takes four coats of zinc white to produce as good a body as three coats of pure white lead will do, thus adding the extra cost of labor and material for one coat over and above the cost of white lead paint. It has, however, many admirable qualities, and may be used for special purposes with advantage; it is rather superior in whiteness to white lead, and is good as a finishing white, or with delicate tints on a ground work of white lead, and may be used in varnishing enamel colors.

If the chemistry of the future can discover a method of manufacturing it with an equal body to white lead, we may safely predict that it will supersede that pigment.

The deleterious effects of white lead upon the health of the workman is a well-known fact. The operative painter is peculiarly subject to its poisonous properties —its effects are seen in the pallid face, care-worn and wrinkled appearance, the attenuated frame, bad breath, and obstruction of the bowels, commonly called painter's colic; in many cases, paralysis follows after colic; we have seen the hands and arms drawn up and distorted and utterly useless. Lead has been found in many cases to have impregnated the whole system. It is scarcely possible for the painter in using white lead paints to escape its effects altogether, however careful and cleanly he may be in his habits, although we have known some who have lived to a good old age without having a day's illness which might be traced to that cause, but we are quite satisfied that much of the ill consequences may be traced to the workman's own want of care and cleanliness. We would strongly insist upon his washing his hands in every case before he touches his food, and clean the paint from under and about his nails. A good practice, which we are glad to see spreading, is to wear linen overalls, cap, jacket and trousers. He should always cast them off before he leaves his work, and not wear them constantly, as some do; he will thus get rid of all trace and smell of paint from his person until work time next morning. On the contrary, the man of careless or dirty habits, who does not adopt these necessary precautions, carries about with him continually the fumes of lead; and when he sits by the fire at home at night, after his day's work is done, the heat will cause a vapor to exude from his garments, carrying with it minute particles of lead, which he and others in his immediate vicinity inhale to his and their detriment. When he is eating, the paint from his hands is transferred to his food, consequently he swallows particles of white lead, thus producing disease and all its attendant train of evils. This is not a fancy picture, but is a stern fact of every-day occurrence, and one which we have seen in numberless instances, and we fully believe that it is this gross carelessness alone that brings to our hospitals three-fourths of the cases of lead poisoning. There can be no doubt but that much of this evil may be avoided by attending to the before-mentioned simple precautions. It is a melancholy fact, that rather than take this small amount of trouble, many will suffer the excruciating pains attendant upon lead poisoning, and fly to gin or other spirituous liquors for temporary relief, thus adding to, instead of diminishing the evil; fat bacon and other fatty meats are considered good as a preventive, as they help to clear the lead out of the system; purgative oils occasionally are useful, but we believe in the good old adage that prevention is always better than cure.

In all there are 27 tramway companies asking for powers over 515 miles of road, with a capital of £4,000,000. For London alone there are 7 companies seeking powers over 125 miles in some of the most important streets; while others have in contemplation systems of tramways for Manchester, Liverpool, Birmingham, Leeds, Glasgow, Portsmouth, and Plymouth.

The caisson for the east pier of the East River bridge is soon to be lowered, to place in 18 ft. of water (mean high tide). Its air-holding qualities have been recently tested and found to be quite satisfactory.

The conflicting accounts in English and French journals, leave us in doubt about the mer.t of Boutet's bridge system.

SUBMARINE WARFARE.

In some recent letters from Capt. J. Ericsson to the editor of "Engineering," the writer offers the following solution to the problem "How to defeat monitors superior in thickness of armor to our own."

A heavy body of regular form, whatever be its specific gravity, projected laterally through the air, commences to fall from the instant of leaving the muzzle of the gun; describing during its progress a parabolic curve considerably foreshortened, owing to atmospheric resistance. But a body of regular form projected under the surface of water or other fluid, in a horizontal or inclined direction, will move in a *straight* line, provided its specific gravity be equal with that of the fluid. In other words, a heavy body of any density whatever moving through the atmosphere, is inexorably under the influence of the gravitating force of the earth; while a submerged body, the weight of which is equal with its displacement, is not affected by gravitation. If put in motion under the surface of a quiescent fluid of unlimited extent, such a body will continue to move in a straight line until the motive energy which propels it becomes less than the resisting force of the surrounding medium.

Starting with these cardinal propositions, I entered, some 25 years ago, on the task of solving the problem of submarine attack, viz., the propelling or projecting below the surface of the water of an elongated shell containing explosive substances to be ignited when reaching some point under the bottom or bilge of an opponent's vessel. The most obvious method of carrying out the idea is that of projecting the elongated shell by means of some contrivance applied near the bottom of the aggressive vessel. Such a method I proposed to the Emperor of France in the month of September, 1854. The device consists of a long narrow chamber arranged near the bottom of the vessel, communicating with the sea and provided with a sliding valve at each end. The outer valve next the sea being closed, the shell is inserted in the chamber, after which the inner valve is closed and the outer valve opened. The means adopted for projecting or pushing out the shell is simply a rod connected with a steam piston. The forward end of the shell being provided with a suitable percussion lock fitted with a protruding trigger, it will be readily understood that when this strikes against an object, the lock, as in ordinary fire-arms, will cause the ignition of the charge within the shell. At close quarters such a method of attack will unquestionably be found very effective—indeed, infallible; but unless the opponent's vessel can be approached very near, it will prove abortive. Evidently, if the shell be projected in any direction not parallel with the line of keel while the aggressive vessel is in motion, a side resistance will be offered by the stationary water of the sea, which will divert the course of the missile the instant it is deprived of the guiding power of the chamber from which it is ejected. Currents will, from the same cause, change the intended course. It need scarcely be observed that, in addition to the difficulty of controlling the direction of the shell, the force imparted to the latter, whether steam or compressed air be employed, is insufficient to propel it to any considerable distance. In order to meet these serious practical objections, viz., that the shell cannot be propelled far enough, and that its course cannot be controlled, I have resorted to a device by which any desirable amount of propulsive force may be imparted irrespective of the distance traversed, and by which the course of the missile is under perfect control during its progress to the intended point. Persons of a mechanical turn of mind, in almost every country, have for a long time been engaged in contriving torpedoes to be propelled under water by independent motive power of various kinds, for the purpose of blowing up vessels. The Austrian torpedo, urged through the water by means of screw propellers actuated by compressed air, may be classed as one of this numerous tribe, the reported terrible nature of which has from time to time frightened naval constructors, and amazed some unmechanical sailors who have witnessed the trials, and found that the mysterious body actually can move under water. Proper investigation of the subject, however, exposes imperfections of the Austrian torpedo which render it,

like all its predecessors, a mere mechanical toy. It should be borne in mind that atmospheric air compressed, so as to exert a pressure of only 300 lbs. to the sq. in., weighs nearly 2 lbs. to the cubic ft. Consequently, the amount of motive force which the torpedo is capable of containing will be found wholly insufficient for its effective propulsion; while the want of means for directing it to the desired point presents an insuperable objection. As before stated, I have contrived a torpedo that may be propelled with any requisite amount of force, irrespective of distance, the course of which is under perfect control, notwithstanding currents, and which may be directed with perfect certainty to an object in motion. In contradistinction to the term *shell*, applied to the structure of 1854, which was propelled alone by *vis viva* imparted, as before described, I propose to apply the term *torpedo* to the contrivance now to be considered.

It should be observed that nearly all attempts to propel bodies under water have been successful as regards maintaining a given depth. The self-evident device of applying a fin or horizontal rudder on each side, operated by a piston or elastic bag actuated by hydrostatic pressure, has been adopted in all. It readily suggests itself to the mind that an increase or diminution of draught, attended as it is with a corresponding variation of pressure, may be made subservient in changing the inclination, thereby establishing a tendency of the horizontal rudder, either to elevate or depress the torpedo during its forward motion. Thus, by a proper adjustment and application of the hydrostatic pressure, the torpedo may be made to move at any desirable depth below the surface of the sea. Nor has any difficulty been experienced as regards the instrument of propulsion in the experiments made since the introduction of the screw propeller. But the difficulty of procuring the requisite amount of motive force for actuating the propeller, and the absence of means for directing the torpedo, have in each instance defeated the object in view.

Before proceeding to consider the important question of *guiding* the torpedo, I will now briefly describe my method of obtaining the required power for actuating the propellers. A reel, of about 6 ft. diameter, revolving on a horizontal axle, is applied near the chamber from which the torpedo is ejected, one end of the axle being supported by a suitable bearing, while the other enters a capacious air vessel through a stuffing box. The end thus inserted in the air vessel is perforated longitudinally for a short distance, and provided with an opening in the side at the point where the perforation terminates. A tubular rope, ½ in. in diameter, composed of hemp and vulcanized rubber, is connected with this opening, and then coiled around the reel a certain number of times, and lastly, connected with the rear end of the torpedo. The air vessel into which the perforated axle of the reel enters, being charged with compressed air (by means of force pumps worked by steam power), it will be readily understood that the compressed air will pass through the axle, then through the several coils of tubular rope wound round the reel, and ultimately reach the rear end of the torpedo, where the rope is attached to the rotary engine which actuates the propellers. Accordingly the propulsion of the torpedo may be regulated by simply opening or closing the aperture of the perforated shaft within the air vessel. The rotation of the reel, consequent on the onward movement of the torpedo, obviously cannot interrupt the passage of the compressed air through the coils of the tubular rope; hence the supply of motive force will continue undiminished during the onward movement. The tubular rope being ½ in. diameter in the bore, it will be found by calculation, that a quantity of compressed air, sufficient to develop at least 10-horse power, may be transmitted through it during the progress of the torpedo, whether far off or near the aggressive vessel. The arrangement thus described being sufficienly simple to be comprehended without entering into detail, it will only be necessary to state that the tubular rope, after leaving the reel under the deck, is made to descend through a vertical tube into the torpedo chamber, in order to prevent an entrance of water at the point where the rope passes out. Also, that *two* propellers are employed, revolving in opposite directions round a common centre—indispensable to prevent the torpedo itself from rotating when subjected to the powerful torsion produced by a *single* propeller actuated by the motive force which may

be transmitted through a tubular rope of ½ in. bore.

I will now proceed to describe my method of guiding the torpedo, premising that the external casing which contains the mechanism and explosive compound, is heavier at the bottom than at the top, in order to preserve a vertical position; and that, in addition to the fins for regulating the draught, the torpedo is provided with a vertical balance-rudder for directing the lateral course. The reel being 20 ft. in circumference, it will be seen that the tubular rope need only be coiled round it 75 times to admit of attack at a distance of 1,500 ft., probably far enough, since the position of the aggressive vessel may be changed at all times with desirable rapidity.

The apparently absurd proposition to direct and change the course of the torpedo at will, on board of the aggressive vessel, without external aid, is solved by the following simple expedient. A small elastic bag connecting the tubular rope with the induction pipe of the rotary engine, is attached to the side of the tiller of the torpedo's balance rudder. As the compressed air during its passage to the motor must pass through the elastic bag, the latter will expand and contract with every change of internal pressure. And as such change will depend on the quantity of compressed air admitted into the tubular rope, the expansion and contraction of the bag is evidently under perfect control. Now the power of this bag to resist internal pressure may be so proportioned that, when maximum pressure is admitted, the swelling of the bag will cause the tiller to move 20 deg. to port; and when the pressure is reduced 25 per cent., the accompanying contraction will move the tiller 20 deg. to starboard. Thus by admitting more or less compressed air into the tubular rope, thereby changing the dimensions of the bag, the tiller will assume any desirable angle within 20 deg. on either side of the torpedo's centre line.

Accordingly, the direction of the torpedo will be as completely under the control of the hand which admits the compressed air to the tubular rope, as if an intelligent directing power resided within the torpedo itself. Probably, no greater mechanical feat than this can be instanced. In smooth water, the telescope will enable the operator to trace the course of the torpedo by the copious formation of air bubbles on the surface of the sea. At other times, a small float attached by a string, will clearly indicate the position; while at night, a small light in the float, seen only from the aggressive vessel, will inform the operator if the missile is on the right road to the intended point. It need scarcely be observed that the explosion of the torpedo will sever the connection with the tubular rope, which thus may be hauled in by turning the reel. Should the intended object not be reached, the admission of compressed air to the tubular rope will be shut off, and the torpedo hauled in, or sent out on a new errand.

The scope of the device, thus described, is, of course limited; yet, had the Italians possessed it, the result at Lissa would unquestionably have been reversed. No harbor can be entered which is protected by it; nor would any amount of vigilance save vessels from destruction on an enemy's coast defended by it; the Hercules and Rupert, with their ponderous armor, would be as easily destroyed as the unarmored Inconstant.

In my recent letter to the editor of "Engineering," it was admitted that the Devastation and consort could steam up the Hudson in spite of batteries and monitors. But small iron-clads of the monitor type without turrets, provided with the reel tubular rope, and torpedoes charged with 500 lbs. of dynamite, could sink Mr. Reed's breastwork monitors before reaching the Hudson.

As stated, the scope of this mechanical device is but limited. Fully impressed with this fact, my labors were early devoted to plans for carrying on submarine attacks by means of which the contest might be removed to the open sea. Before the close of the late war, the problem was satisfactorily solved; and during the month of November, 1866, the leading features of a new system of naval attack were confidentially laid before the King of Sweden and Norway, the Swedish Minister of Marine, Count B. von Platen, and Commodore A. Adlersparre.

Let me add, for the information of your readers, that my object in giving an account of my labors connected with submarine warfare, is simply that of demonstrating the futility of encasing ships of

war with huge masses of iron, and showing the absurdity of wasting millions of tons of coal in propelling weight which does not protect.

A NEW SYSTEM OF SUBMARINE ATTACK.

In the above communication I stated as a general proposition: that a heavy body of regular form, of any density whatever, moving through the atmosphere, is inexorably under the influence of the earth's attraction, and therefore describes a foreshortened parabolic curve during its flight; while a submerged body, the weight of which is equal with the weight of the water it displaces, is not affected by the earth's attraction ; and that consequently, if put in motion under the surface of a quiescent fluid of unlimited extent, such a body will continue to move in a *straight* line until the motive energy which propels it, becomes less than the resisting force of the surrounding medium.

In virtue of the first part of this general proposition, a heavy body may be projected in such a manner that the termination of its trajectory shall make any desirable angle, less than 45 deg., with the horizontal line, independently of the length of the chord of the trajectory. In other words, the body may be projected at *variable* distances over water, and yet strike its surface at any desirable angle. This important result is effected simply by varying the relative proportion between elevation and strength of charge. The second part of the stated general proposition is of equal importance. It points to the fact that the trajectory may be extended in a straight line under water, to any desirable distance, irrespective of the *speed* of the projectile. Accordingly, a shell may be projected from one vessel towards another within moderate ranges, in such a manner that it shall dip into the water at a considerable distance from, or close to, the vessel assailed, independently of the distance between the two vessels. Also that the shell may be projected at such an angle that the prolongation of its trajectory in a straight line, after contact with the water, shall strike the hull of the vessel assailed, at any desirable depth below the surface.

That a certain relation between charge and elevation enables us to project a *spherical* shot, with considerable accuracy, in such a manner as to strike the water at any desirable distance from an opponent's vessel, at angles within 45 deg., will be admitted. Hence, if the trajectory be such that its extension in a straight line from the point of contact with the water leads to the hull of the vessel assailed, the latter will be hit—on condition, however, that the shot is not diverted on entering the water; and provided its *vis viva* be sufficient to overcome the resistance encountered during its passage through the water. These indispensable conditions, which apparently cannot be complied with, point to the difficulty of hitting a vessel below the water line. And if we suppose that the projectile is not spherical, another serious difficulty presents itself. An *elongated* body will not bend to the curvature of the trajectory, but retain during its flight the same inclination as the gun from which it has been projected ; hence it will fall nearly flat on the surface of the water at the end of its course.

Agreeable to our general proposition, a regular body, weighing as much as the water it displaces, is independent of the earth's attraction ; but there is another force which, notwithstanding the absence of any gravitating tendency, will cause a body of regular form moving under water to deviate from a straight line and rise to the surface. A cone moving in the direction of its apex and in the line of its axis horizontally, or on an incline, will, owing to the inertia and the nearly incompressible nature of water, more readily displace the column which rests upon and depresses its upper half, than the column from below with its lifting tendency. Consequently, the course of the conical body will be diverted from the straight line upwards, describing a curve nearly elliptical, and quite sudden, if the speed be great. A cylinder with semispherical ends will, from the same cause, ascend to the surface if moved in the line of its axis ; while a cylinder with flat ends will take a downward course, gradually increasing its inclination until at last the axis assumes a vertical position. Obviously, the lower part of the forward flat end encounters a greater resistance than the upper part ; hence the lower half of the transverse section of the cylinder suffers an excess of retardation, which occasions the downward course described.

The question whether the apparently insuperable difficulties thus pointed out

may be overcome by mechanical expedients, has, as already stated, occupied my attention for a long time; and numerous experiments have been made to test the efficacy of devices resorted to on theoretical considerations. But it is not my purpose to enter on a description of these devices at present, on grounds that will appear hereafter. Accordingly, I will assume that the axis of the elongated projectile during its flight through the air is parallel with the trajectory, and that on entering the water the projectile will not be diverted, but continue to move under the surface, with the same inclination it had on coming in contact with the dense medium.

The accompanying sketch presents the main features of my new system of submarine attack so distinctly, that it will be superfluous to enter on a general explanation of the nature of the scheme. It may be well to state, however, that the elongated shell is charged with dynamite and provided with a percussion lock and trigger, to be actuated as described in my former communication relative to the self-acting torpedo.

It is well known that numerous plans have been suggested during the last few years, for firing under water, for the purpose of piercing the hull of iron-clad vessels below the point protected by the armor. In several instances these plans have been carried into practice with the invariable result that the resistance of the water has been found so great, even at very short distances, that an ordinary wooden hull has proved to be impenetrable. The plan now under consideration bears no resemblance to these projects. In the first place, the attack is made at a distance; and, secondly, the force of the missile on reaching its destination, need only be sufficient to actuate the trigger which causes the ignition of the explosive charge.

Apart from the theoretical considerations relating to the course of the elongated shell under water, the practical question of *motive power* to propel the same presents itself at the first step in the investigation. It is hardly necessary to state that the force relied upon is the *vis viva* possessed by the shell on coming in contact with the water. Before estimating this force it will be proper to call attention to the fact that my new system, to be effective and a practical success, does not call for attack at a great distance, provided the vessel from which the missile is projected has greater speed than the opponent, and at the same time adequate protection against his artillery. No reason whatever can be assigned why the attack should not be successful, and the destruction of the vessel assailed as certain if the distance of 500 ft. were the limit, as if a range of 5,000 ft. better suited the new system. It will be inferred from this explanation, that although there is no special limit within ordinary ranges, the plan is to attack at distances not much exceeding 500 ft., unless the sea be very smooth.

The *vis viva* of a shell 15 in. in diameter, of such a length that it displaces 500 lbs. of water, may be readily estimated if we suppose the charge of powder in the gun to be so regulated that the shell will enter the water at the required rate of 400 ft. per second; thus, $\frac{400^2}{64}=2500\times 500=1{,}250{,}000$ ft.-lbs. A cylindrical body 15 in. in diameter, with semi-spherical ends moving at a rate of 50 ft. per second under water, requires a constant motive force of somewhat less than 400 lbs. Assuming, then, that the shell passes through 120 ft. of water—the mean distance represented by the accompanying diagram—we have a resistance of $120\times 400=48{,}000$ ft.-lbs. to overcome. The motive force, it will thus be seen, is more than 24 times greater than the resistance; hence no doubt can be raised as to the adequacy of the motive power furnished by the *vis viva* of the shell. It should be observed, that the resistance is very great at first, and that the speed of the shell diminishes in a very rapid ratio; but it would be futile to present a formula expressing the ratio of speed and resistance since the *form* of the body is the chief element in the calculation. Suffice to say, that while the resistance against a blunt body is so great that it can hardly be overcome, one provided with a sharp point enters the water with much facility, even at the rate of 400 ft. per second. The passage of the shell through the water will, therefore, be sufficiently rapid to reach the desired object in proper time.

With reference to the gun, it should be borne in mind, that the very low speed of the shell, and the consequent small charge

of powder needed, render heavy metal unnecessary. Besides, slow burning cake-powder contained in cellular cartridges, will be employed for the purpose of checking rapid ignition, and in order to sustain an uniform pressure during the discharge. By reference to our sketch it will be seen that the guns are loaded from below, and for that purpose so arranged as to admit of being depressed 60 deg. Gun carriages are dispensed with, the trunnions being suspended by adjustable pendulum links secured under the turret roof. The recoil is checked by buffers attached to the turret wall in rear of the breach.

I feel called upon to state, that loading guns below deck, as here shown, was planned by me, and drawings representing this method exhibited in New York several years before it was claimed by certain American engineers as their invention.

Respecting the safety of the charge in the shell from ignition during the discharge, it will be well to observe that efficient means have been devised to prevent such an accident. With reference to the *calibre*, it is evident that this system of attack calls for dimensions that will admit a shell of sufficient capacity to contain a charge which by its explosion will destroy a first-class ship of war built on the cellular plan. Nothing short of 300 lbs. of dynamite will suffice for this purpose ; hence nothing less that 15-in. calibre will answer. The American and Swedish 15-in. guns are admirably calculated for the purpose, although they are unnecessarily heavy.

European savans, especially certain Swedish naval artillerists, who have criticised my advocacy of the 15-in. smooth-bore gun, will understand on looking into this matter, why I have persisted in advising the Scandinavians to carry this large calibre in their monitor turrets as the most effective weapon against their powerful neighbors. Assuredly the Danes will have no cause to fear the Prussian König Wilhelm or Friederich der Grosse, when their ports are defended by vessels armed with guns by means of which 300 lbs. of dynamite may be exploded under the hulls of the intruders.

The important question of hitting the intended object will be best answered by a careful examination of the accompanying diagram, which cannot fail to convince naval men that, in moderate weather, the elongated shell may be made to dip at the proper distance from an opponent's vessel. The diagram clearly shows that no great accuracy is called for, and that the shell may dip at various distances from the vessel assailed and yet strike the hull. It should be observed that the vertical scale of the diagram is different from that of the horizontal, in order not to place the vessels too far apart for the limited size of this page ; consequently the trajectory shown is distorted.

The turret, it may be briefly noticed, in which the light 15-in. shell guns are mounted, is composed of flat wrought-iron plates forming a square box, wide enough to accommodate the two pieces, suspended as already stated, by pendulum links secured under the turret roof. A massive central shaft of wrought-iron supports the square box, on the plan adopted in the monitor turrets. The vessel designed to carry the rotating square box with its light shell guns is a mere iron hull crammed with motive power, in order to insure a higher speed than that of existing iron-clad ships of war. The midship section is triangular, and the bow raking, as indicated by our sketch. (See Frontispiece.) The overhanging sides and deck are heavily armored.

Permit me to add, that I intend to make a formal offer, under certain stipulations, to furnish, at my own cost and risk, a swift screw vessel provided with a pair of 15 in. smooth-bore guns, and the necessary apparatus for sinking by submarine explosion, a vessel of the average draught of the iron-clad fleet of England, while such a vessel is being towed at the greatest speed possible, or performing whatever evolutions her owner may choose, with the distinct understanding that the attack shall not be made at a less distance than 500 ft. Accordingly, it has not been my purpose on this occasion, to enter into a full description of my new system of submarine attack. It may be well, however, to define clearly what the scheme is intended to accomplish. If a first-class swift iron-clad ship, say the Devastation, unassisted by other craft, will meet in open water a vessel constructed agreeably to the new system, it is contended that the latter will sink the breastwork

monitor in spite of her guns and impregnable armor, and notwithstanding evolutions designed to avoid the submarine missile.

THE STABILITY OF ARCHES.

Translation from "Exposé de la Situation de la Mécanique Appliquée."

Though arches have been constructed from very ancient times, no attempt was made to treat the problem of their equilibrium in a scientific manner until the last century. La Hire and Couplèt made the first attempts; the first complete theory is due to Coulomb. His results have been verified by experiments on models, of which those of M. Boitard may be specially mentioned.

The theory of Coulomb consists in expressing the equilibrium of each portion of the arch between the crown and the plane of any joint. Each of these portions is solicited by its own weight, by the weight of its load, and by the reactions of the contiguous parts of the arch. It is generally admitted that the pressure at the crown is horizontal; this supposes that the arch is symmetrical, and that it is loaded symmetrically with reference to a vertical plane through the crown. As the point of application of the thrust is not known, it becomes necessary, in discussing the conditions of equilibrium, to suppose it placed in succession at the highest, the lowest, and intermediate points. For the equilibrium of each portion of the arch thus isolated, it is necessary that there should be no tendency to sliding at the joint, and no tendency to rotation about either of the edges. These various conditions are expressed by several inequalities, in which the thrust at the crown and the ordinate of its point of application are involved. They should be formed for all the courses of voussoirs between the crown and each joint; and equilibrium will be possible if all these inequalities can be satisfied by a positive value of the thrust, and a value of the ordinate at the crown comprised between the corresponding limits of the thickness of the arch. If this determination is possible, it is still necessary to stability that the load at any point shall not exceed the limit of resistance imposed upon constructors.

The theory of Coulomb is complete; but it will not be found convenient in practice, if it is not subjected to a geometrical transformation, first pointed out by M. Mèry in an article inserted in "Les Annales" of 1840. This method depends upon the consideration of the curve or polygon of pressures. If the thrust at the crown were given in magnitude and position, it would be sufficient to compound it with the weight of a portion of the arch lying between the crown and any given joint, load included, in order to determine the reaction of the portion situated beyond the plane of the joint. The geometrical construction of this reaction would show whether there was a tendency to sliding or rotation; for there would be no tendency to slide unless the resultant should make with the normal to the joint an angle greater than the angle of friction between the voussoirs; and there would be no tendency to rotation so long as the line of mutual reaction passes through the joint, and not beyond it. Hence, if the thrust at the crown is given, the polygon of mutual reactions at the joints can be traced by compounding this thrust successively with the weights of the voussoirs and their loads. To insure equilibrium this polygon should cut all the joints in the arch, and should intersect them nearly at right angles. The locus of the points of intersection of the successive reactions, become at the limit, when the voussoirs are of infinitesimal thickness, the *curve of pressures*. Instead of referring to the actual planes of the joints, it is usual to divide the arch by vertical sections, in order to compound the thrust at the crown with the weights. This slightly alters the trace of the curve, but gives it a useful geometrical property, viz., that of representing the mutual reactions by tangents. The curve is then entirely analogous with funicular curves, in which the tension has a tangential direction. This property of the curve of pressures does not generally hold when the planes of separation of the various parts of the arch are inclined to the directions of the forces.

The curve of resistance is thus far defined, if its point of departure at the crown, and the direction and intensity of the thrust, are given. It is expressed by a differential equation of the third order, the integral of which contains three arbitrary constants. The curve may, therefore, be subjected to the condition of passing through three arbitrary points, and these are usually taken at the crown and at the springings. If the arch is symmetrical to a vertical plane through the crown, these three points may be symmetrical, so that the curve will be so. This is the most general case. The thrust at the crown is thus made horizontal. Very simple geometrical construction gives the magnitude of the thrust at any point; and the trace of the curve can be obtained by dividing the arch into small elements. When the curve is entirely comprised within the thickness of the arch, its distance from the intrados will not generally be constant at all points. The *joint of rupture* occurs where this distance is the least possible. It is here that the materials of the arch suffer the greatest pressure, and where rupture takes place if the distance between the curve and the intrados is too small. The joint of rupture opens along the extrados, and a crack extends across the spandril. If the curve of pressure approaches the extrados the joint tends to open toward the intrados.

These tendencies appear in all arches that can be observed, and the trace of the curve of pressure explains the facts which the old experimenters observed, but could not account for. Thus, in arches having the form of an arc of a circle, the joint of rupture is near the springing, and generally causes a crack in the spandrils in consequence of the opening of the joint at the extrados. In full semicircular arches there is a slight tendency to open towards the intrados at the crown, and towards the springing lines; while at an equal distance from these joints, at the joint of rupture, there is a tendency to open in the opposite direction.

The problem of the curve of pressures, as we have seen, is indeterminate; since the equation of construction contains 3 arbitrary constants in the general case, and 2 when the arch is symmetrical. This indicates that in a statical point of view, there are an infinite number of possible equilibriums; but one of these actually exists. If the real laws of molecular action were known, we should have the conditions necessary to determine this particular equilibrium. But we are arrested in this research by our ignorance of the actual laws. An attempt has been made to introduce into the problem considerations of the minimum value. The problem thus becomes determinate, but this determination is arbitrary, and there is nothing to prove that it is warranted. It seems to leave out of view special conditions of relative position, which though difficult to express in the calculus, still have a preponderant influence upon the distribution of pressures in the arch. M. Drouets has considered the problem from another point of view. In a fine memoir published in the year 1865, in "Les Annales des Ponts et Chaussées" he has discussed the results furnished by the method of M. Mèry, and, with the aid of ingenious geometrical considerations, has been able ot determine a curve of particular pressures, which satisfies the general conditions which make equilibrium possible. If it pass beyond the limits of the arch or show too great local pressures, it is certain that equilibrium is not possible.

Builders generally take for points of intersection the tiers superieur from the crown and the middle of the joint at the springing, a method which is expeditious, and in most cases sufficient.

The method of the curve of pressures, like that of Coulomb, from which it is derived, is a method of verification of equilibrium rather than a method of *invention* of the form of the arch. It has been of great service in reducing the thickness of arches and relieving them of a load which tended to destroy instead of strengthening them. But the forms authorized by long practice have not been modified by the influence of the new theories. An attempt has been made to determine by the calculus the best form to give to arches. M. Yvon-Villarceau has published a very interesting paper upon this subject, in which he delineates the lines of arches of equal resistance. The results of this analysis have not been introduced into constructions. M. Carvalho published in "Les Annales des Ponts et Chaussées," in 1853, a paper in which he endeavors to find the best form for the extrados of an arch of which the intrados is

given; and he determines the line, so that the curve of pressures of the loaded arch coincides with the curve of pressures of the arch without its load. The tables given in this memoir are useful in constructions.

In a practical point of view, the problem of the arch may be regarded as almost solved. The formulas given by Perronet are generally applied in determining the thickness at the crown and at the pieds droits. An inequality gives the inferior limit of thickness necessary to prevent tipping about the outer edge of the base; it is obvious that this does not increase indefinitely, as the height of the pied droit increases. Tables and empirical formulas more or less complex determine the principal elements of the construction. Builders, it is true, do not agree upon certain points; as, for example, upon the question of the change of thickness between crown and springing.

The equilibrium of arches when centred, is a problem still quite obscure. It was formerly treated by Couplet and afterwards by Perronet, who, in the construction of the beautiful bridges at Nantes and Neuilly, employed trussed centres of surprising lightness. The method of the curve of pressures now solves the problem in a more rational manner; but the complete determination of the strains developed in the centring, and in the arch, supposes the resolution of the problem of deformation of the centring, which requires a calculus very complicated and probably inextricable. Hence, engineers who deal with the question avoid the difficulty by reversing the problem. They admit that the centring makes the curve of pressures parallel to the intrados. This hypothesis makes known the action of the centring upon the arch, and may guide in the choice of forms to give to the carpentry.

THE SELF-PURIFICATION OF RIVERS.

From "The Engineer."

It is frequently asserted that history repeats itself, that events take place in recurring cycles, and that everything mundane tends to return to its normal condition. Upon this last hypothesis must, we think, be based the argument of those who have stated, and still maintain, that polluted and contaminated waters will, under certain circumstances, by a process of self-restoration, return to that state of pristine purity with which they were endowed by nature. This erroneous idea has long since been exploded in our editorial columns, and will receive its death-blow from the confirmation our views with respect to it have received in the recently issued Report of the Rivers' Pollution Commission. As we admitted then, we admit now, that a certain amount of purifying action is produced upon large volumes of running water by exposure to the air; but we emphatically now deny, as we denied then, that this can be justifiably termed a purification, or regarded even as an approximation to their restoration to their original purity, cleanliness, and sweetness. What was the assertion put forward by those who were interested in first polluting a river with sewage, and subsequently stating, in attempted justification of their conduct, that the contamination was but of a trivial and temporary nature? Their statement was, "that if sewage be mixed with twenty times its volume of river water the organic matter which it contains will be oxidized and comparatively disappear whilst the river is flowing a dozen miles or so." Were a million gallons of sewage to be discharged into the Amazon or the La Plata near their sources, it is possible that but little vestige of its injurious or offensive properties would remain by the time it was wafted to the shores of the Pacific. But the case assumes a different aspect when the scene is transferred to our own country and our own streams, and when the incessant daily discharge of sewage bears a proportion in volume to the contents of the channel of its reception which renders the process of self-purification of the latter a physical impossibility. To imagine that it could be otherwise would be tantamount to maintaining that a perpetual cause can produce only a temporary effect. There was a time in England, as there still is in all thinly populated and undeveloped countries, where purity was

the ocean, pollution the drop. Now the position of affairs is reversed; contamination is the ocean, purity the drop; and in the majority of instances the drop is so infinitesimal that it eludes the power of every agent that science, chemistry, and analysis can employ for its detection.

If we were asked, what are the causes of river pollution? our answer would be, everything that is capable of rendering water foul and contaminated. There is not an offensive, impure, or noxious substance that does not at some period or other find its way into a watercourse. There are, notwithstanding, several foreign ingredients in water that do not necessarily render it impure in the sense of injurious. Water may contain suspended and dissolved bodies which may render it unfit for drinking or domestic purposes, but which do not cause it to be either dangerous to health or offensive to the senses. Dismissing the terms pure and impure, and substituting those of polluted and unpolluted water, the chemical difference in their composition is the important fact to keep in view. A natural or unpolluted water frequently becomes turbid, or, to use the common phrase, dirty, from natural causes alone, but it is not thereby polluted. The contamination is only apparent, not real—only mechanical, not chemical—and can readily be removed by the employment of mechanical means solely. An unpolluted water may be recognized by being inodorous and tasteless, and by possessing a very faint alkaline reaction. It contains in 100,000 parts about 0.5 of carbon, and 0.1 of nitrogen, in the shape of organic matter, and is also endowed with the distinguishing feature of being incapable of putrefaction, although exposed to a summer temperature for some length of time in close reservoirs and vessels. Classing the numerous sources of river pollution under the two general heads of sewage and manufacturing refuse, it is the organic constituents of the former class that impart both the most offensive and most injurious properties to our streams and watercourses. Their amount of organic carbon is at once raised from 0.5 to 2.0, and of organic nitrogen to 0.75. An infallible sign that a stream has been polluted with sewage is the presence of chlorine, assuming always that its waters do not flow—like those of the Weaver, for example—in the neighborhood of salt deposits, either solid or fluid. To afford a good idea of the comparative state of purity to which the waters of the Thames near Hampton have been brought, it will be sufficient to refer briefly to the results of the analysis made by order of the commission of the Thames water and that of the Lancashire rivers. If the pollution of the Thames at Hampton be represented by unity, the maximum amount of that of the Lancashire rivers by organic carbon and organic nitrogen will be 6.5 of the former and 49.3 of the latter. It is rather curious that there is a greater degree of contamination in the streams of Lancashire in winter than in summer, although, for obvious reasons, it is not so apparent. This is one of those facts that would not be suspected, and probably would be strenuously denied until proved to be true by the unerring test of analysis.

Returning to the immediate subject of our article, namely, the statement that rivers—or, generally speaking, running waters—possess a remarkable power of self-recuperation, it must be borne in mind that hitherto this has been a bare assertion, never proved, or attempted to be proved in any manner whatever. It might be imagined that those who ventured upon so wholesale and sweeping an opinion would have taken some care to have at any rate a slight foundation upon which to erect so extensive a superstructure. Unfortunately for their argument, it was left to the commission to set the matter at rest one way or the other, as the members considered it of the highest importance that the truth should be known respecting a question which involved the health and welfare of all our large cities and towns. A favorable opportunity presented itself during the visit of the commissioners to the basins of the Mersey and Ribble for making the experiment, which was conducted with the same care and impartiality which characterize all their proceedings. The three rivers, the Mersey, the Irwell, and the Darwen, after being polluted to the last degree, have an average flow of 12½ miles without receiving any further contamination, although their respective volumes become considerably augmented by the accession of unpolluted affluents and tributaries. This disturbing cause must be taken into account when the results of the experiments are considered. Samples of the water at the

two extremities of the above distance were taken, and their composition ascertained by chemical analysis. The temperature plays an important part in the process. When it does not reach 64 deg. Fahr. there is very little effect produced by the flow upon the organic matter dissolved in the water. Taking the mean of the experiments upon these three rivers, the percentage reduction of the organic elements after the flow of 12½ miles was for organic carbon 10.98, and for organic nitrogen 8.58. In order to eliminate the element of uncertainty introduced into the calculation by the variable composition of the waters, which it should be borne in mind was all in favor of the self-purifying action, one volume of filtered London sewage was mixed with nine volumes of water. The mixture was carefully analyzed, and freely exposed to the light by siphoning it in a slender stream for several days from one vessel to another, the fall being three feet. It is not necessary to enter into the details of the conclusions arrived at. It is sufficient to state that the results indicate very closely the effect which would be produced by the flow of a river or stream containing 10 per cent. of sewage for 96 and 192 miles respectively, at a rate per hour of one mile. The percentage reduction of the organic carbon in the first distance would be 6.4, and of organic nitrogen 28.4. For the latter distance the corresponding figures are 25 1, and 33.3. As the temperature during this experiment was nearly 70 deg. Fahr., it demonstrates that the oxidation of the animal organic matters in sewage proceeds very slowly. It was also demonstrated by another experiment on the rate of oxidation of sewage, that supposing a river polluted with the above proportions of sewage received no further contamination for a distance of 168 miles, it would then lose about 62.3 per cent. of its injurious and offensive properties. Is there any river or stream in England which could fulfil those conditions? Granting that only one discharge of sewage took place, it might be safely inferred that there "is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation."

In addition to the conclusive results arrived at by the commissioners, it was proved by the evidence of landowners situated eight or ten miles down the stream from the town where the pollution originated that the water was "utterly foul, slimy, thick, and seething." If we examine into the cause of the belief by many persons of the self-purifying power of running water, it will be found in the identity they suppose to exist between clear and pure water. A stream will, during its flow, deposit a large proportion of the grosser and visible impurities which are held simply in mechanical suspension. The turbidity of it, or, in plain language, its dirtiness, will thus be plainly decreased; but the amount of the *dissolved* impurities will remain the same. The water will *look* cleaner, but chemically will be as dirty as before. But, although the stream deposits by subsidence the mud or other substances mechanically suspended in it, they are not by these means rendered innocuous. On the contrary, in flood times and during summer this deposited sediment becomes stirred up and putrescent, and when collected proves to be "disgustingly offensive." After the facts laid before them, our readers are fairly warranted in dismissing all idea of the self-purifying powers of running water, not, perhaps, as Sir Benjamin Brodie observed in his evidence, as "absurd," but as practicable only under conditions the fulfilment of which is impossible.

QUICK PASSAGE TO BOMBAY *via* THE SUEZ CANAL.—The Bywell Castle, steamship, belonging to Messrs. Palmer, Hall & Co., arrived at Bombay on the 16th ult., after a passage of 35 days from the Thames, including 3 days occupied in passing through the canal.

SUEZ CANAL.—Direct steam communication between Holland and her Eastern dependencies (Java, Sumatra, Sunda Islands, etc.) *via* the Suez Canal, is being organized at Amsterdam, under the honorary presidency of Prince Henry of the Netherlands, brother to the King of Holland.

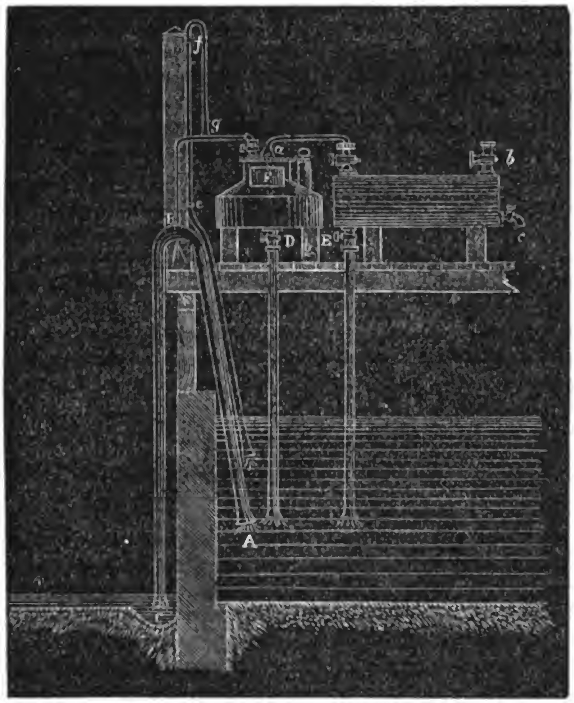
THE elevated railway in Greenwich street, in this city, is (as usual) announced to be about ready for public patronage.

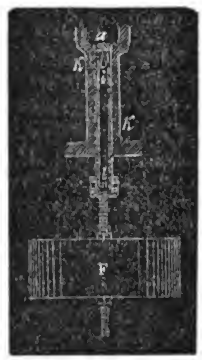
SIPHON AND SUCTION PUMPS.

Translated from "Les Mondes."

M. de Lagillardais has invented an apparatus which utilizes in many ways the simple phenomenon of the discharge of liquids, or of liquids mixed with gas, through tubes bent in a vertical plane like the ordinary siphon.

The pressure determines the direction and the continuity of discharge in these tubes. A discharge being induced in the first siphon, will cause a suction of the air contained in a tube communicating with its top; this again will set the second siphon in action. It is obvious that by means of a combination of siphons and of





prises d'air, which cause the *pulverization* of the liquid in the ascending brandies, the pressure can be regulated.

Of the two siphons referred to, the first takes the name of suction siphon, with reference to the second, which, because its effect is like that of the common pump, is called the siphon pump. The first siphon acts as a motor to the second ; it makes use of a fall of water to produce the suction which raises and carries the liquid over.

The *priming* (*amorçage*) of the suction siphon is affected by means of an apparatus called the *priming reservoir.*

A *primer,* a suction siphon, a communication betwen suction siphon and pump siphon, *ajutages,* are the elements employed by M. de Lagillardais.

The figure (A) is an illustration of the apparatus.

A suction siphon, using the head of a certain quantity of falling water which passes through B C to a lower level, produces a suction in the pipe *e*, and finally a discharge from the receiving reservoir through the orifice *c*. The details may be easily understood from the figure. The priming reservoir is set at the common level of the top B, and of the receiving reservoir; it communicates with the race by a vertical tube provided with a stopcock D. This priming reservoir communicates with the top of the siphon B and with the receiving reservoir. Suppose this to be full of water ; by opening its connections with the race and with the suction siphon, the others being closed,

the priming of A, B, C, will be caused by the fall of water. As soon as the suction siphon is in action, its communications will cause action in the priming reservoir, which will be ready at any time to renew its action after the operation has been interrupted by any cause; and also to renew the action in the receiving reservoir. A manometer, *c*, *f*, *g*, will show the force of suction. The communications of the different parts of the apparatus require regulation. This is automatically accomplished by a valve, shown in detail in Fig. B. F is a float acting upon a valve *a*, connected to it by a hollow stem which guides the socket *k*. At *i* are the orifices regulating the admission of air into the primary reservoir.

In Fig. A, the suction siphon and the siphon pump dip into the same layer, so that a part of this layer is lifted at the expense of the other, which acts as motive force. Generally speaking, the priming reservoir, the suction siphon and the pump siphon, when communicating with their upper connections, correspond to distinct layers of the liquid. The levels of the priming reservoir and of the tops of the siphons may also be independent.

In the most complex case, as represented in Fig. A, in which the reservoir is above the priming reservoir, it would be necessary to fix a pulverization *ajutage* at the bottom of the ascending tube of the receiving reservoir, and to adjust the suction pump accordingly.

The applications to which M. de Lagillardais proposes to adapt this apparatus are numerous. He mentions, in particular:—

The priming and the maintenance of the action siphons employed in the drainage of liquids; especially siphons discharging a basin at high tide.

2. The elevation of liquids and all kinds of drainage.

3. The production and maintenance of a vacuum; and as a consequence the freezing, condensation, and evaporation of liquids in a vacuum.

This apparatus is new and ingenious. It seems to be available in the utilization of those natural forces which so often remain unproductive.

UNION PACIFIC ENGINEERING.

From "The Iron Age."

We are indebted to Gen. G. M. Dodge, late Chief Engineer of the Union Pacific Railroad, for a copy of his Report, December 1, 1869, to President Ames, giving a connected history of operations in his department, with reports of Chiefs of Parties during the years 1868 and 1869.

We preface an abstract of the most valuable portions of the Report, with a sketch of the

EARLY SURVEY,

and Mr. Dodge's connection therewith. In 1853, Henry Farnham and T. C. Durant, who had the contract for building the Mississippi and Missouri road (now the Iowa division of the Ch., R. I. & Pac.), instructed Peter A. Day to investigate the question of the proper point for that road to strike the Missouri river, to obtain a good connection with any road that might be built across the continent. General Dodge was assigned to the duty, and surveys were extended to and up the Platte Valley, to ascertain whether any road built on the central or then northern line would follow the Platte and its tributaries over the plains, and thus overcome the Rocky Mountains. Subsequently, under the patronage of Mr. Farnham, General Dodge extended the examination westward to the eastern base of the Rocky Mountains and beyond, examining the practicable passes from the Sangre Christo to the South Pass; made maps of the country and developed it. The practicability of the route, the singular formation of the country between Long's Peak, the Medicine Bow Mountains, and Bridger Pass, on the south, and Laramie Peak and the Sweetwater and Wind River ranges, on the north, demonstrated that through this range the road must eventually be built. He reported to Mr. Farnham, and through his and his friends' efforts the prospect for a Pacific road began to take shape.

In after years surveys were extended through the country previously explored, and its capabilities for the building of a railway to the Pacific fully demonstrated.

In doing this over a country covering a

width of 200 miles, and on the general direction of the 42d parallel, some 15,000 miles of instrumental lines have been run, and over 25,000 miles of reconnaissances made.

DIFFICULTIES ENCOUNTERED.

In 1863 and 1864 surveys were inaugurated, but in 1865 the country was systematically occupied; and day and night, summer and winter, the explorations were pushed forward through dangers and hardships that very few at this day appreciate, as every mile had to be run within the range of the musket. Numbers of our men (says Mr. Dodge), some of the ablest, were killed; and during construction, stock was run off by the thousand; and as one difficulty after another arose and was overcome, both in the engineering, running and construction departments, a new era in railroad building was inaugurated. Each day taught lessons by which they profited for the next, and the advances in the art of construction were marked by the progress of the work; 40 miles of track having been laid in 1865; 260 in 1866; 240 in 1867, including the ascent of the Rocky Mountains, 2,235 feet above the ocean; and during 1868, and to May 10, 1869, 555 miles, all exclusive of side and temporary tracks, of which over 180 miles were built in addition.

The first grading was done in the autumn of 1864, and the first rail laid in July, 1865. When one looks back to the beginning at the Missouri river, with no railway communication from the east, and 400 miles of the country in advance without timber, fuel, or any material to build or maintain a road, except the sand for the bare road-bed itself, with everything to be transported, and that by teams, or at best by steamboats, for hundreds and thousands of miles; everything to be created, with labor scarce and high, we can all look back upon the work with satisfaction.

FINAL LOCATION.

Its location has been critically examined, and in regard to the correctness of the general route, no question is ever raised; and even in the details of its location, 730 miles of which were done in less than 6 months, it has received the praise of some of the ablest engineers of the country. Its *defects are minor ones*, easily remedied, and all the various commissions have given the company due credit in this particular.

In January, 1858, Mr. Dodge received instructions for that year. He was to finish the location to Green River by June 1, to Salt Lake Valley by autumn, and before winter, to develop the country west of Salt Lake. He made ample arrangements to accomplish this. James A. Evans, in charge from Laramie to Green River, having four parties who took the field in March, the snow being deep, and Mr. Blickensderfer, with three parties, to locate from Green River to Salt Lake, who took the field in March. Mr. Evans completed his survey by May 2, and Mr. Blickensderfer his in July, both before the time set.

In April, the Vice-President informed Gen. Dodge that "he desired to cover the road with men from Green River to Salt Lake within one month, and to Humboldt Wells in three," and notwithstanding no intimation had been given, and no arrangement made to carry out such a programme, he succeeded in completing the location over the difficult work, and over a large portion of the light work, before the contractors could get on the road. The forcing of the parties forward so fast, over so difficult a country, gave no time to review lines, and re-examine or re-run them on the ground. West of Green River and down Bitter Creek there was no preliminary line standing as a guide, the surveys by Evans and Reed in 1864 being obliterated. The locating engineers lost no time by any party; but worked day and night, even to the full seven days of the week.

BROWN'S PASS TO GREEN RIVER.

From Brown's Pass, latitude 41 deg. 50 min., to Green River, latitude 41 deg. 38 min., the line is so direct that on the ground it does not increase the distance over an air line 5 miles in more than 200, and in the measurement by longitude the increase is not perceptible. This location has no grade to exceed 65 ft. per mile; no curvature to exceed 6 deg., and in the detailed location its per cent. of curve line is one-sixth, of tangent five-sixths.

In the Rock Creek country, the contour of the ground has been too closely followed, and too much curvature is used, a matter easily remedied hereafter. With this and other slight exceptions, the location

is fair, the grades easy, curvatures light, alignement very direct, the water-ways ample, and the resources of the country, with its coal beds, made available. The grading, mostly in embankment, is 1 to 2 ft. higher than appears necessary in the summer, so to avoid the snows of winter, the economy of which has already been demonstrated by the diminished ability of that portion to obstructions from snow. The location down Bitter Creek is a good one—bold, direct, and made with an intelligent view of the commercial value of a line, as determined by alignement and grades, as well as mere cost of construction. The question of a supply of water between North Fork of Platte and Bitter Creek received serious consideration in 1867. The running of construction trains was difficult, most of the water having to be taken from North Platte; yet time brought a fair supply at all the wells, and now trains run without detention.

The alkali and soda-water district extends from the Laramie to Green River, but they take water from mountain streams and springs, from the Laramie to North Fork of Platte, throwing all the bad water on one division, Rawlins to Green River.

GREEN RIVER TO MOUTH OF WEBER.

Gen. Dodge's examinations of 1867 had satisfied him that the true route was north of Salt Lake. It was desirable to get a more direct line than by way of Weber Valley. Of all the passes over the Wasatch that at the head of Blacksmith Fork alone remained, and it was considered important to definitely settle its character.

Mr. Hodges' examinations determined the impracticability of the Blacksmith Fork route, which would have saved 40 miles and given a much better direction.

A careful examination of the located line, as well as of all the other lines surveyed, either then or afterward by the construction department, convinced Gen. Dodge that the line adopted is superior to any other. No other compares with it in a commercial value; and in avoiding obstructions from snow, no other is equal to it.

Considering the character of the country, the

LINE FROM PIEDMONT TO PROMONTORY

may be considered a remarkable one, crossing three ranges of mountains, passing for 60 miles through the gorges of the Wasatch, and descending from an elevation of over 7,000 feet above the ocean to one of less than 4,300. This line of *two hundred miles in length*, in the magnitude of the work required, does not much exceed the 200 miles eastward from Piedmont, comprising the valleys of Black's Fork, Green River, and Bitter Creek. Nature did much to render it comparatively easy to overcome the great obstacles which had been looked upon as the most formidable barriers to the road, and, by a skilful location, the work per mile in cubic yards was rendered very light, and should not, under ordinary circumstances, have cost over 25 per cent. more per mile than for the same distance east of the rim of the basin. But the cost was often doubled and even trebled and quadrupled. This is accounted for by the untoward circumstances under which it was pressed to completion, and not by any large amount of work per mile, or peculiarities, location, or its mountainous character.

MOUTH OF WEBER TO HUMBOLDT WELLS.

The best line for grades and curvatures would have been to cross Bear River arm of the lake, eight miles in width, but they found from 12 to 22 ft. of water, a permanent rise of 9 ft. since 1863. This forced them to adopt the line north of Bear River Bay, substantially that run in 1867 for the Central Pacific Railroad.

The prominent features are the mud flats skirting the north of the desert; the crossing of Promontory Point; the passage of a spur of Raft River Mountains by Red Dome Pass; turning of Raft River Mountains proper by Rosebud Creek; passage of Omber or Pilot Peak range by Surprise and Passage Creeks; the climbing of Toano Mountains, 1,270 ft. above desert, by a continuous 60 to 65 ft. grade; and the passage of these mountains by Ives' Pass; the Pegnoss Range by Pegnoss Pass; Cedar Range by Cedar Pass, and of the Humboldt Mountains by that natural depression at the head of the valley of the Humboldt, at Humboldt Wells.

There had been so much said about building over the mud flats that a thorough investigation was made. Where water stood on them it was found that they be-

came harder, and 2 ft. below a *clayey subsoil existed*, capable of sustaining a roadbed. Below, quicksand was often met; but with a high bank, giving proper drainage, a bed could be properly sustained, if properly ballasted. He therefore crossed the flats where alignement or grade demanded it.

Promontory Point, the most difficult summit to make, and where the most intricate line, the heaviest work, the highest grades, and the sharpest curves occur, is a bold backbone running north and south, 600 ft. high, with scarcely 4 miles of direct ascent from the east, and 12 of descent on the west, devoid of natural ravine or watercourse. To approach the summit the line has to cling to the rough sides of the ridge, and gain distance by running up Blue Spring Creek Valley, and winding back again on its opposite side. Lines of 70, 80 and 90 ft. grades were traced on the western slope, and the 80 and 90 ft. were so nearly equal that it required a careful adjustment of each, and close estimate, to determine which was entitled to the preference. Finally, the 80 ft. line was adopted, and considerably improved. The 6 miles on the east slope has heavy work and a few 6 deg. curves as a maximum, and is by far the most difficult portion of the line west of Weber Canon. After surveying a number of lines they made a location over it. Subsequently, they adopted the 83 ft. grade line.

Grading at this point was not commenced until Feb., 1869, and from the material to be moved, with the track rapidly approaching, it became necessary to work night and day, and increase teams without regard to economy. Eight hundred thousand yards of material were taken out by contractors in the early stages, costing $623,000 ; while 178,000 yards, under the day system, when working night and day shifts, cost $618,000. This fact shows that the company spared neither money nor labor to gain time in the final completion of the road. The descent on the west is made with 53 ft. grade, and light work. The mud flats are crossed, and Monument Point reached at an elevation of about 4,300 ft. The western shore of the lake, near Monument Point, is bold, where boats could easily land.

Red Dome Pass, 600 ft. above the lake, is ascended with a continuous 65 ft. grade, no curves to exceed 6 deg., and very light work. The descent is slight for 20 miles to Terrace Pass, from which the line, descending to the level 30 miles, skirts the north rim of the great desert. This 30 miles is a tangent almost the entire distance. It there enters the valley of Surprise Creek, crosses it with 12 miles tangent, and makes the ascent of the Toano Mountains with a 60 ft. grade, probably the most remarkable ascent on the continent, as 900 ft. of elevation is made with a continuous 60 to 65 ft. grade of 14 miles in length, with no cut or fill to exceed 10 ft., and no curves to exceed 4 deg.

The remarkable feature of these mountains is their long foot slopes, with a contour so uniform that almost any elevation can be obtained without heavy work. Toano Mountains are passed by Ives' Pass, from which the line diverges to the north, down a tributary of Thousand Springs Valley, with easy grades, to the intersection of Pegnoss Creek, which is ascended to the summit of Pegnoss Range at Pegnoss Pass. The line then makes almost directly west into the valley of Independence Creek, from which it rises to Cedar Pass, and then descends by clinging to the long slopes with 60 ft. grades, to Humboldt Wells, where the location ends at an elevation of 5,587 ft. above the sea. The line is remarkably cheap for such a mountainous country, passing 6 ranges at right angles in 232 miles.

It is remarkably direct, will be free from snow, passes through a country a great portion of which is susceptible of cultivation, well enough timbered with cedar and pine sufficient for all practicable purposes, with mountain streams, affording a fair supply of water.

North of the desert the valleys are heavily bedded with grass, and the hillsides covered with bunch grass of the finest quality. The country allows a very good alignement, avoiding extreme curvature and no grade over 65 ft., with very light work except on Promontory.

ROUTES AROUND SALT LAKE.

General Dodge became satisfied that the northern was the true route. As the company desired a comparison of the two, he *examined both personally*, and ran several instrumental lines on the south side, full details of five being obtained, but one of which required comparison with the north line.

The south line would connect with the main line just west of Ogden, from Humboldt Wells 301.3 miles, as against 225 miles by the present road. This line avoids the Promontory Mountain with its heavy grades and work, but, instead of 5 miles of 80 ft. grade, has three times as many miles over Goshoot Pass with 90 ft. grade, and nearly three times the amount of work passing the Toano Mountains.

This comparison shows conclusively the superiority of the northern over the southern line, being shorter by 75.15 miles, having less ascent and descent, and a less elevation to overcome and less curvature. The total cost of the north line is about $2,500,000 less than that of the south line would have been, besides the difference as a purely engineering question.

MATERIALS ON THE LINE.

Timber and Stone.—Near the heads of the watercourses in the mountains a sufficiency of timber within available distances can always be found for the ordinary repairs of the road in replacing ties for buildings, and for other local uses, but not of a quality suitable for large or important railway structures. Good building-stone will be more difficult to obtain, as much supposed to be durable, from the presence of some element yet unknown, proves to be, when exposed to the atmosphere, entirely unreliable and useless. There are, however, some quarries of good stone on the road.

Ballast.—The road-bed is very largely composed of sand, gravel, and loam, which of themselves sustain a track well, and the climate is so dry that neither the autumnal frosts nor the spring thaws affect the ground materially, and the track can be sustained with an expenditure much below the average of other roads.

IMPROVEMENTS.

Since the junction of the two tracks a large force has been kept at work, bringing the road up to the Government standard. Between Wasatch and Ogden all the temporary bridges over large streams have been replaced with permanent structures, and the road has been fully ballasted. The temporary tracks are all abandoned. Between Bryan and Wasatch a heavy force has been preparing the foundations and putting in the masonry for permanent bridges over the large streams, and the superstructure is all on the ground.

Large gangs have been at work on the road-bed; the banks are widened, the cuts sloped, and now very little remains that is of pressing necessity.

All grades ascending both eastward and westward can be reduced to 60 ft. per mile, except those over the three mountain ranges, should the commerce of the road demand it; and, in many cases, by judiciously taking out cuts for ballast where sharp curves now occur, the curvature can be much ameliorated.

MISSOURI RIVER BRIDGE.

The Missouri River is now the only obstacle between the Atlantic and Pacific, and as the transfer is now made it is an unnecessary tax and annoyance to travel and traffic. The U. P. R. should receive all passengers and freight on the east bank, placing the transfer in the hands of one company and under one management.

The U. P. R., by law, has its terminus on the east bank, and its charter has been so drawn as to give it all the rights and privileges necessary to do this transfer by itself, or an agent, or by contract.

It is an unnecessary tax to force four competing roads to each put in boats to do a business that one road can do for all four, and the cost of maintaining these four tranfers is sufficient to prohibit in a close competition a large amount of through traffic.

The completion of the bridge at an early day is a necessity, and our experience is now such that we can push the work at almost any rate of speed directed.

To avoid filling our columns disproportionately, we have prepared the following abstracts of several valuable tables contained in the Report:

BUILDINGS, SIDINGS, ETC.

Of the 150 points on the road at which these buildings have been erected, 100 are stations, and 50 have merely section houses, tool houses, windmills, etc. The structures are as follows:

Freight Houses	12	Circular Houses	10
Tanks	51	Iron Houses	4
Turn Tables	11	Paint Houses	3
Coal Houses	17	Storehouses	15
Tank Houses & Tanks	27	Coach Houses	1
Engine Houses	8	Tool Houses	197
Stationary Houses	9	Section Houses	199

Watch Houses	6	Paint Shops	2
Tank Master Houses	2	Founderies	4
Bridge Master Houses	1	Telegraph Offices	10
Tank Engine Houses	4	Civil Engineers' Offices	2
Baggage Houses	2	Tank Master's offices	1
Warehouses	7	Offices	15
Pump Houses	31	Depots	72
Battery Houses	5	Stables	2
Ice Houses	5	Sheds	1
Oil Houses	9	Sawmills	1
Bridge Houses	3	Burnettizers	1
Wood Pile Houses	2	Hotels	6
Agents' Houses	8	Hotel Wings	1
Machine Shops	6	Sleeping Rooms	7
Blacksmith Shops	9	Company Stores	2
Car Shops	3	Woodsheds	1
Repair Shops	3	Windmills	50
Car Repair Shops	1		

The amount of side track is 472,547 ft.—89.5 miles; the total length of line, 1,085.875 miles. Of this total

THE GRADES

are as follows:

		Miles.
Level		200.47
0 to 20 ft.	Ascent	325.17
	Descent	116.03
20 to 40 ft.	Ascent	162.498
	Descent	112.229
40 to 60 ft.	Ascent	49.835
	Descent	48.817
60 to 80 ft.	Ascent	41.889
	Descent	14.576
80 to 90 ft.	Ascent	......
	Descent	14.491
Total Ascent, ft		13,087.34
Total Descent, ft		9,336.88

THE ALIGNEMENT

is as follows:

Degree.	Radius.	Miles.
$\frac{1}{6}$	34377	2.67
$\frac{1}{4}$	22918	0.49
$\frac{1}{3}$	17188	0.20
$\frac{1}{2}$	11460	22.514
$\frac{3}{4}$	7639	1.487
1	5730	44.315
$1\frac{1}{2}$	3819	2.836
$1\frac{2}{3}$	3437	2.47
2	2864	38.467
$2\frac{1}{2}$	2292	4.105
3	1910	30.343
$3\frac{1}{2}$	1637	2.336
4	1432	26.422
$4\frac{1}{2}$	1273	0.952
5	1146	12.971
$5\frac{1}{2}$	1042	0.53
6	955	5.292
Length of Tangent		887.458
Length of Curve		198.420
Degree of Curvature, right	11,698.39	
Degree of Curvature, left	12,446.22	
Total Curvature		24,144.61

BRIDGES, CULVERTS, AND TRESTLE-WORK.

The total number of these structures was, at the date of the Report, 1,402,—aggregating 69,281½ ft. or 13$\frac{1}{10}$ miles. Of these, 41 were Howe truss, 10,070 ft.; 10 strain beam bridges, 420 ft.; 3 Post truss do., 485 ft.; 2 Post combination do, 890 ft.; 376 trestle, stone abutments, 30,385 ft.; 74 trestle, on pile, 6,228 ft.; 223 pile bridges, 16,731 ft.; 40 stringer do., 591 ft.; 49 stone arch culverts, 571 ft.; 373 stone box do., 817 ft.; 20 wood box do., 37½ ft.; 59 open stone do., 372 ft.; 132 open wood do., 1,684 ft.

CONDENSED HISTORY OF STEAM.—About 280 years B. C., Hiero, of Alexandria, formed a toy which exhibited some of the powers of steam, and was moved by its power. A. D. 450, Anthemius, an architect, arranged several caldrons of water, each covered with the wide bottom of a leather tube, which rose to a narrow top, with pipes extended to the rafters of the adjoining building. A fire was kindled beneath the caldrons, and the house was shaken by the efforts of the steam ascending the tubes. This is the first notice of the power of steam recorded. In 1543, June 17th, Blasco D. Garay tried a steamboat of 209 tons with tolerable success, at Barcelona, Spain. It consisted of a caldron of boiling water, and a movable wheel on each side of the ship. It was laid aside as impracticable. A present, however, was made to Garay. In 1650, the first railroad was constructed at Newcastle-on-Tyne. The first idea of a steam-engine in England, was in the Marquis of Winchester's "History of Inventions," A. D. 1663. In 1710, Newcomen made the first steam-engine in England. In 1718, patents were granted to Savery for the first application of the steam-engine. In 1764, James Watt made the first perfect steam-engine in England. In 1763, Jonathan Hulls set forth the idea of steam navigation. In 1778, Thomas Paine first proposed this application in America. In 1781, Marquis Jouffroy constructed one in Saone. In 1785, two Americans published a work on it. In 1789, William Tymington made a voyage in one on the Forth and Clyde Canal. In 1802, this experiment was repeated. In 1782, Ramsey propelled a boat by steam to New York. In 1783, John Fitch, of Philadelphia, navigated a boat by a steam-engine on the Delaware. In 1793, Robert Fulton first began to apply his attention to steam.—*The Iron Age.*

THE STRENGTH OF ROLLED SECTIONS OF IRON.

From "The Engineer."

There is obviously a limit at which it becomes more economical to employ a solid section of rolled iron than to "build one up," as it is technically termed; but where that limit is to be found engineers are by no means agreed. Some even contend that under all circumstances a built-up section is to be preferred, while others, on the other hand, advocate the adoption of the "joist" under conditions of span and load for which it is certainly not adapted. Without the slightest intention of attempting to act as an arbitrator in the matter, it may be stated that there is an ambiguity attending the calculation of the strength of all rolled sections of iron from which the built-up type is comparatively free. Let us select as a commencing example a rolled joist and a built-up one having the same depth, span, and the same net area of bottom flange. If the breaking weight be calculated, and the same constant used, the two beams will be equally strong; but what a relative disproportion exists in the two webs! Owing to the practical exigencies of the rolling process it is impossible to make the web of the one approach in thickness, or rather thinness, to that of the other. It is also true that, in instances in which the span and load are small, the web of a plate beam must, at least in the central portion, be in excess of the theoretical shearing strain upon it; but the discrepancy is slight compared with that of a rolled joist under similar conditions. Supposing, however, that we have an example where the web of the built-up or plate beam is not more in excess of its theoretical requirements than what always attends the reduction of theory to practice. In the rolled beam intended for the same weight and span the area of the web will very much exceed that of the plate girder. How is this increase of area to be allowed for? The thicker the web evidently the greater the strength of the beam, although the increase of strength will be nothing like what might be perhaps anticipated. It must not be forgotten that there is very little use in accumulating material at or near the neutral axis. In other words, it is not in the web, but in the flanges, the metal is most serviceable, since its moment of resistance is in direct proportion to its distance from the neutral line. Theoretically, the web is regarded as imparting no element of strength to the girder, but has its influence confined to two points. The one is to possess sufficient stiffness to keep the flanges apart, and the other to be sufficiently strong to support its own shearing strain. Compared with the strain upon the flanges, this duty is very light, as will be seen by selecting an example. Suppose a girder to have a span of 100 ft., a load per foot run of one ton, and a depth of 8 ft. For a girder of this size the web would be double, and the maximum normal strain upon each end at the abutments would be 25 tons, whereas that upon either flange would be 156.25 tons.

It might be argued that a rolled joist may be regarded as a solid beam with a part cut out, and so it might; but this view lessens neither the ambiguity nor uncertainty of the calculation. Some engineers do treat rolled joists in this manner, but there are no data in theory nor experiments in practice to prove the conclusiveness or the soundness of such treatment. It is impossible, with the present limited and scanty information we possess, to be able to estimate what proportion of the area of the web acts as a solid beam, and ought to be estimated as such. Evidently the whole area ought not to be included in the calculation, for a part of it is absolutely necessary to maintain the relative connection between the flanges, and it is on that assumption that their own strength is estimated. If two separate calculations be made, one for the strength of the flanges, and another for that of the web, and the total net area of the web be included in the latter, then part of it is estimated twice over. It is not to be understood that it has actually been included numerically in the formula, but that it has virtually been allowed for. Should it be argued that it has not, then we have the astonishing problem of a flange of a beam supporting a heavy strain without any web at all. The whole difficulty arises from the fact of considering a rolled joist as a girder of compound parts, in which the total strength consists of the separate resistances of the flanges and web.

That they do mutually assist one another there is no doubt; but it is impossible to draw the line of demarcation, and to tell where the action of one ceases and that of the other begins. The advocates of the solid-sided or plate system of girder allege that the continuous web relieves the flanges of as much as one-sixth of their longitudinal strains; but this is doubtful. Without venturing upon such extreme statements, the part played, or supposed to be played, by the web, when of extra thickness, in assisting the flanges, might be allowed for by adding some of its area to that of the bottom flange in the formula, and thus virtually calculating the strength of the beam as if it had a bottom flange of a greater area. Unfortunately, the unknown quantity in this simple equation is the amount of web area that should be included in it; and as this must be known before the equation can be solved, the solution is, practically, not determinable.

When once a rolled beam is considered in the light of a simple flanged girder, all uncertainty respecting its ultimate strength vanishes. We know that its strength can never be less than that calculated upon the above assumption, since the extra thickness given to the web may strengthen but can never weaken the flanges. Until some more reliable data and information is at our disposal the influence of the additional thickness of the web of a rolled beam may be cautiously allowed for by assuming a higher constant than that used for the plate or lattice girder. The value of this constant might be safely taken to be equal to 80, which supposes that no flexure can possibly take place in the web —a condition that cannot be asserted to be always fulfilled in either a lattice or a plate girder. The effect of any appreciable deflection or yielding taking place in the web upon the flanges is to bring a transverse strain upon them, which they are not adapted to resist; and, consequently, whenever there is a chance of this, the constant must be lowered in value, or the breaking weight, and thence the actual weight or working load, will be in excess of the strength of the structure. Some reliable experiments are really required, carried out with a view to determine the actual difference in the breaking weights of rolled and built-up sections of iron, so that the value of the additional thickness in the web might be accurately ascertained. The span, load, depth, and net area of flanges being the same, the discrepancy between their breaking weights, if any, could always be allowed for by deducing the corresponding constant.

ON SHIP BUILDING.

From "The Scientific Journal."

At a meeting of the institution of Naval Architects of London, on the 17th ult., a paper was read on the "Load-draughts of Merchant Ships," by Mr. W. W. Rundell. The proper draught for a merchant vessel, said the author, is not a question to be determined in the first place by science, but by experience. Science may lend her aid in generalizing and defining the results of experience, but must unhesitatingly accept the dicta of those whose position and practice make them the real arbiters of the question. The naval architect and ship-builder must bow, like others, to the decision of these experts. The load-draught cannot be arbitarily fixed by the naval architect. Lloyd's rule, three inches to the foot depth of hold, or the scale of the Liverpool underwriters, may be quoted; but these blind no one Lloyd's rule was a suggestion only, and it was made when iron ships were just being talked of, and when few ships except East India men, exceeded 700 or 800 tons, and it has never been recognized by Lloyd's Committee, except as an approximate guide for the loading of certain classes of vessels. The Liverpool scale is intended only for first-class vessels, and is subject in all cases to the judgment of the surveyor, who is influenced by the age and class of a vessel, its general proportions, the intended voyage, the nature of the cargo, and other circumstances favorable or otherwise. The experts who practically rule in these matters are certain surveyors more or less intimately connected with the underwriting bodies, and who, if not practically appointed by ship owners, have secured their confidence.

Their great experience enables them to judge very closely as to the draught of water at which a ship begins to damage her cargo or become otherwise unsafe. Wooden vessels are now passing away, and iron sailing ships are being largely superseded by steamers. Iron sailing vessels will in future be chiefly employed in long voyages, and new ones will probably be of large size. As regards iron vessels, therefore, considerations depending on their age, the nature of the voyage, the season of the year, as affecting their load-draught, may be omitted nearly altogether. Considerations arising from the kind of cargo may also be omitted, as it is generally acknowledged that with proper care, and by incurring the expense necessary for making good stowage, any proportion of dead weight may be safely carried. There remain only those conditions which relate to form and proportion, and these, I submit, are sufficiently represented by adopting the customs measurements and registered tonnage. The suggestion that $\frac{3}{10}$ths of the whole displacement is a proper proportion for buoyancy was made years since by Mr. J. Jordan. The author then proceeded to refer to various tables bearing on the subject of his paper; and alluding to the requirement of more free sides for large wooden ships than for small ones, he said that the reasons assigned for it were not applicable to iron ships. Large iron ships can be as strongly built as small ones. There can be little objection to the $\frac{3}{10}$ths displacement scale for ascertaining when a sufficient quantity of cargo has been placed on board a vessel. But it makes no allowance for extreme length, or for the length and character of the waves she may encounter. The surveyors state the extreme length in proportion to a vessel's other dimensions, must be considered; but, so far as I am aware, they have not defined to what extent. Like the surveyors, I have not come to any difinite conclusion on the subject, but wait for better instructions. Like other scales, which point out with more or less exactness what is the proper load-draught for a vessel, they leave us in ignorance as to what amount of departure from it will render a vessel relatively unsafe or practically unseaworthy. After some observations as to the desirableness of some mode of ascertaining the point at which a ship becomes dangerously laden, the author concluded by the following practical suggestion: Let a round spot 9 in. in diameter, be conspicuously painted on every vessel over 300 tons register on each side, midships, at a point through which a horizontal plane would pass, which would cut off the upper one-fourth of the vessel's registered tonnage when she is on an even beam. This would be useful in indicating pretty accurately when the $\frac{3}{10}$ths of the whole vessel are out of water. In vessels of about 500 tons this mark should be fully its own diameter above water. In vessels of 750 tons it would be two diameters above water, in larger ships two and a half diameters. Here one kind of instrument would be needed to make the observation. If the spot were very near the surface of the water the ship would certainly be very fully laden; if it touched the water she would be very deeply laden; if immersed or out of sight she would be dangerously laden. This would not hurt the ship-owner in any way. The proposed mark would indicate a fact, not an opinion.

Mr. Laport was of the opinion that no fixed rule could ever be satisfactorily used and applied to vessels of all descriptions. The strain upon a vessel in a sea way depended a great deal more upon the disposition of the cargo within the ship than the actual weight in reference to the capacity of the ship and amount of free board. An instance came to his notice in which a vessel was about to sail, when the captain discovered she was not laden to the proper line, so as to develop her best sailing capacities. He therefore placed 7 tons of lead in the extreme part of the stern, and so brought her to the right position. When such a vessel got to sea those 7 tons of lead would produce a blow as of a tremendous hammer at the stern of the ship, and would almost be destructive of an old or improperly constructed vessel. Another thing which would militate against the adoption of any ordinary rule was that in some ports through which a river runs, vessels were borne by fresh water, which weighed 62 lbs. to the cubic foot; but at sea the water weighed 64 lbs. to the cubic foot. Thus if an arbitrary rule would unjustly press upon ships loading in such a port as Sunderland, as compared with Liverpool, where the buoyancy of the water was greater, the discharging part of the cargo

when a vessel was overloaded was not always beneficial, and it might disturb the proper arrangement of the cargo. The captain might be obliged to take it out where he best could, and thus the vessel might be rendered unsafe. One of the reasons why vessels at present were so overloaded was, that at Manchester it was customary, in order to economize freight, to press the goods to such an extent that they really ought to be estimated as dead weight. No account had been taken of this matter as connected with steamers in the paper. When a steamer started, particularly if she carried the whole of her coals, for a long voyage, she starts with a certain load drag arbitrarily fixed and insisted upon by Lloyd's surveyors. She might be a vessel to burn upwards of £50 per day; thus each day's consumption would lighten her to a considerable extent. Was this variation not to be taken into account, and an arbitrary rule to be fixed for all vessels, whether steamers or sailing vessels? Other points must be considered, such as the time she had existed, and what material she was formed of. If it was an iron ship, every year a certain amount of oxidated matter would be shelled off, and imperceptibly her plates would become thinner and thinner; so her intrinsic strength to discharge her duty became less and less. Was there an iron vessel which was registered at Lloyd's, of a certain class, for twenty years, after nineteen years of sloughing off her strength, to be loaded in the same way and to the same extent as when she was first registered? Was a vessel built by Messrs. Wigram or Mr. Samuda to be put in the same category with others pitchforked together by some little ship-builder? The best guarantee, after all, on which the public could rely, was the character of the owners, and builders, and insurers of a ship.

Mr. J. Dudgeon said some years ago he built a steamer for trading in the North Sea, but subsequently found she was too shallow; that if a heavy cargo was put in her the upper deck would be too near the level of the sea. He therefore heightened her 7 ft. 6 in. After he had done this he still found she was not deep enough, and he put a full poop into her upper deck, and a year or two afterwards a new forecastle, and she was now one of the finest ships that ever went to sea. With the materials at present at command, vessels might be made as high out of the water as any one wished, so that it would be absolutely impossible for water to come on board. No iron ship should be built in any other way than with the bottom sufficiently strong to carry the whole of the superstructure, while the superstructure was in the nature of a house with a roof to it. The moment this point was arrived at, the question of vessels foundering at sea would be forever put at rest. On the 29th of December, four years ago, five ships left the same port, one of them being the vessel he had altered in the way he had described, and that was the only one of the lot ever again heard of. The reason that one escaped was because she was built 7 ft. higher out of the water, and in the violent gale in which the others perished, instead of lodging on top to the weight of hundreds of tons, passed off her decks. The other vessels were laden with iron above the water where it was not required, instead of at the bottom. Yet this was the only vessel out of the five that could not be classed at Lloyd's. He believed in a few years the absurd regulations now enforced by the various societies would all be done away with. No force of wave would penetrate a plate of iron one-eighth of an inch thick. Until these sensible views were adopted no good would result. Another point requiring attention was the steerage power of our vessels, which, as a rule, was not so good as it ought to be, our method of applying the power of the rudder, especially in single screw steamers, not being quick enough to meet the necessities of the sea.

Mr. C. H. Wigram thought as the proposed variation was so small as not to amount to more than 3 or 4 in. with a depth of hold of 28 ft., it would only be complicating matters to depart from the present understood rule. The proposed line would be useless as applied to steamers which rapidly varied their draught of water, while it was an admitted principle by all surveyors that steamers might be loaded deeper than sailing vessels. The way the cargo was stored was really of much more importance than the free board. Some years ago a ship laden with an enormous quantity of railway iron stored in bulk and carrying emigrants, got into very bad weather and was compelled to put into

Cork, her topmasts having been carried away. Instead of discharging any of the cargo the captain altered the position of the iron, brought it up from hold, and put it under the berths between decks. This so steadied the ship that she made a very quick and safe passage to New York. Too little attention was at present paid to the stowage of a vessel. A ship was chartered by a certain broker, his object being to get as much into her as possible, and as a rule his stevedore stored the cargo without any reference to the wishes of those who managed the vessel. An owner who allowed such a practice to prevail in regard to his vessels could not justly complain if he met with misfortune. With regard to what had been said about the depreciation of iron ships, it happened curiously enough that this year the Indus, which was one of the first iron vessels, was cleaned and the inside paint taken off the plates, and although she had been built over 22 years, there was no appreciable diminution in the thickness.

Mr. C. Henwood thought the load-draught was a matter which ought properly to be fixed by naval architects. He did not see much difficulty in settling the load line, but he was quite sure it could be done by taking the total capacity, or the length or breadth of a ship, as the basis. He had never heard any reason, however, why it should not be determined from the displacement only. A margin of 25 per cent. of the total displacement might be given for buoyancy for cargo ships, and 50 per cent. for passenger ships. Free board, as a matter of safety, was not of great importance, although of course lofty decks were more comfortable than low ones. He approved of the suggestion made by the council of the Institution, that certain papers should be supplied to the captain of a ship, giving the profile and 1 or 2 sections of spaces. If the centre of gravity of those spaces in relation to the centre of gravity of the ship were recorded on those sections, the stevedore would have a point to start from in filling up the hold.

Captain De Horsey said it appeared to him that the great merit of Mr. Rundell's system was that it did not lay down any dogmatic rule applicable to all ships. Of course, the load line of ships must vary considerably according to her age and the trade she was engaged in. No rule could be stringently applicable to a passenger vessel and to a collier. The system which had just been proposed would simply fix the spot representing one-quarter of the displacement, leaving it free to have the load line so much above or so much below that spot for each particular ship.

Mr. Samuda, M.P., said, although he did not agree with that part of the report of the committee on this subject which recommended that certain things should be made imperative upon the public, he did not by any means think the question should be shelved, or put on one side, on account of its difficulty. Although an absolute solution might never be arrived at, a great deal more might be learned upon the subject by future investigations, so as to guide and direct each individual who might be responsible for carrying out any of the plans recommended. He thought good might be effected if constructors of vessels were compelled to take the responsibility of pointing out with every ship leaving their yards the maximum point at which they would recommend it to be loaded, without making it absolutely obligatory upon the persons who accepted the vessels to follow those recommendations. No doubt great difficulties would have to be encountered in attempting to carry out such a plan. It would involve an elevation in the position of those who would be responsible for giving their recommendations to their clients, which their clients were not at the present moment disposed to recognize. The imposition of an imperative law, which should allow no variation in any way, would be very likely to result in doing exactly the reverse of what they most desired, and would lower the amount of information, and prevent the useful application of the knowledge of naval architecture. Their object should be to acquire and disseminate a much more general information as to the course to be followed by ship-owners, and not at such an early stage to restrict by legislative enactments, or to draw a hard and fast line for the guidance of all.

Mr. Scott Russell said if a customer required an unsinkable ship any good builder could build one ; but if this plan were generally adopted what would become of insurance brokers and other persons of a similar occupation ? He had such a faith

in iron and such a contempt for water that he felt it was quite possible to build vessels that nothing could sink. When a ship is delivered by the builders part of the papers should consist of plans and information for the captain as to the stowage, the centre of gravity, the stability, and the surplus and margin in a ship. It might be required as a portion of the preliminary examination of the captain before getting his certificate, that he should be able to intelligently use those plans.

Mr. W. N. Fenning said it was a lamentable fact that losses of vessels had been very much more frequent during the last three or four years than during the previous fifteen or twenty years. Many of those vessels, too, were what ought to have been fine vessels in which the public could place reliance. He was perfectly convinced that overloading was the cause of an immense proportion of these losses, and until this subject was dealt with in a straightforward manner, the evil would go on increasing. There were ship-owners and ship-builders against whose ships not a word could be said; in fact the vessels of one firm could be insured in Australia 20 per cent. less premium than any other vessels afloat. An owner who inspired such confidence in the public and the underwriters could not suffer by any proper investigation of this subject; he would rather benefit by any law against overloading, because the premiums on all vessels would be lowered. The loss of life by the present want of definite rules was also very terrible. The objection to a fixed rule based on the different buoyancy of fresh and salt water might be met by making an allowance for the difference. Steamers should not be overloaded on the chance of meeting with fair weather until a quantity of coal had been consumed to lighten them to a proper load-draught. If any committee were appointed to inquire into this subject, practical men, members of the different insurance companies, members of Lloyd's, should form part of that committee.

Mr. Rundell, alluding to an expression of opinion which had fallen from the chairman yesterday, said Mr. Inman had upwards of £50,000 interest in the City of Boston uninsured, while he had spent at least £100,000 more in searching for the missing vessel. Replying to the objections made to his proposed system he said that he had regarded the smallness of the difference between the scale of three-tenths displacement, and the scale for Lloyd's, as one of the merits of the proposal. It appeared to him a most extraordinary remark that it would be easy to fix the proper draught for a vessel quite independently of the free side. If the ship were a parallelopiped, then the ratio of the depth of the box would be a very fair indication of the proportion that should be above water, and if it were proposed to have $\frac{1}{4}$ above water, of course $\frac{1}{4}$ of the lineal depth would be the exact amount, and he could not see how $\frac{1}{4}$ of a vessel could be kept above water irrespective of the depth of the side. Although there might be conditions requiring that the length be considered, depth appeared to be the first element taken into account. The application of his system to steamers had not escaped his notice, but the shortness of the time allotted to a paper prevented his discussing that point. The distribution of the weight of cargoes did not affect the draught.

The chairman explained that he had not intended to say anything offensive or injurious to the Messrs. Inman. In his allusion to the City of Boston, he merely expressed his opinion that the agent in Halifax, who had contradicted the report that the vessel was overladen, was the person who had the strongest interest in maintaining such a view of the case. Returning to the more immediate subject of discussion, he said it would not do to rely always on the character of the owner, the builder, and the captain, as suggested by Mr. Laport, for those persons frequently differed in their views. Captains were frequently prevailed upon against their better judgment to overload their vessels, but if they would all take a firm stand, and act according to their own knowledge of the capabilities of their ships, the number and frequency of casualties by sea would be very considerably diminished. A public man, when he took up a great subject, had no business to look to the right or to the left; he should regard only the safety of the public, and he did not hesitate to say that ship-owners and ship-builders were not free from the infirmities of human nature. Great exertions must constantly be directed to the restraint and tendency in human nature to self-interest, and for the safety of the pub-

lic, that restraint was as beneficially exercised when imposed upon owners and builders of ships, as when imposed upon any other class of society. Those who set an example to the rest of the profession of attending to the proper construction and sea-going qualities of their vessels, reaped their reward, in the fact that they could insure their ships upon more favorable terms than other persons. It would not be right to disregard the loss of property, the frightful loss of life, and the loss of national character resulting from such an astounding catalogue of casualties as that which they had heard during the past few months. He perfectly coincided with Mr. Fenning, that many of these had occurred from the fact that ship-owners had yielded to the temptation to load their ships deeper than was safe. The ship was frequently loaded to the extent the ship-owner thought she ought to be, looking to the whole voyage she is to make, and then, in addition to that the coal is added. That such was the case was shown by a number of instances in which the casualty had occurred within a very few hours after leaving the port.

OBITUARY.

Died, on the 27th of April, at Belmont, Mass., by his own hand, ZERAH COLBURN. The funeral took place in Lowell, Mass., on May 4th.

Besides his wife and daughter, and other relatives, there were in attendance such members of the engineering profession as were aware of his decease, and could accommodate their engagements to the short notice given. Among them were Mr. J. B. Francis, Mr. John Souther, Mr. Geo. Souther, Mr. John A. Haven, Mr. John C. Hoadley, Mr. A. L. Holley, Mr. John B. Winslow, Mr. L. B. Tyng, Mr. E. H. Barton, and Mr. Wm. Burke. Hon. Wm. J. McAlpine and others attempted to be present, but were prevented by the shortness of the notice.

The following account of his brief but brilliant career is from the pen of his former associate, Mr. A. L. Holley, contributed to the "New York Times":—

The name of Zerah Colburn is known to the engineers of all countries where professional literature exists, and his writings are perhaps more various in scope, and more vigorous in practical treatment, than those of any other member of his profession. In his death engineering sustains an irreparable loss.

Mr. Colburn was born in Saratoga, N. Y., in 1832, and was named after his uncle, the celebrated mathematician. His father died soon after, and his mother, very poor and infirm, removed to New Hampshire, where, during his boyhood, young Colburn earned his living on a farm. His early means and opportunities for acquiring an education were limited to a few months' attendance at a district school, a short clerkship in a factory, and such books as he could find in a remote country village. But his industry and his wonderful memory more than made up to him then, and throughout his life, his want of early advantages. From an odd volume of the old "Penny Magazine" he gained a knowledge of the world and an inspiration to see and figure in it, which all educational appliances fail to give the average boy of the period. At the earliest possible moment, young Colburn left the wilds of New Hampshire and struck out for civilization, and he kept moving until he finally settled down in its midst—in London. His first sight of a city, and, what was a greater thing to him, a locomotive, was at Concord. The strong but hitherto undeveloped mechanical talent in him at that sight asserted its proper place, and the locomotive was ever after his chief study, and the subject of his best conclusions and ablest writings.

He soon after, as he found means for support, removed to Boston. His first literary attempt was in verse for the "Carpet Bag." His professional career commenced on the Concord Railroad,* under the late Charles Minot, then its manager, who was attracted by the brightness and practical ideas of this singular youth. In a few months Colburn had mastered the anatomy and physiology of the locomotive engine, tabulated the dimensions and proportions of those under his observation, and published a small, but excellent and still useful, treatise on the subject. He then got a subordinate position, and soon rose to the superintendence of the locomotive works of Mr. Souther, in Boston. Here he tabulated and committed to memory (an easy task for him) the dimensions of all parts of the then standard locomotive, and the cost of all the materials and labor employed in its construction. With the exception of a few months at the Tredegar Works, at Richmond, where, in connection with Mr. Souther, he started the manufacture of locomotives, Mr. Colburn then made New York his head-quarters until 1858. His more important professional work at this time was his superintendence for a year or more, of the New Jersey Locomotive Works at Patterson, during which engagement he made some improvements, still standard, in the machinery of freight engines.

Although eminently fitted for the management of practical construction, Mr. Colburn early found that the literature of engineering was his true calling. He therefore joined the "Railroad Journal" of this city, in which, professional readers, soon recognizing the hand of a master, began to look for a new era in technical journalism. And they were not disappointed. In 1854, Mr. Colburn started, in New York, the "Railroad Advocate," a weekly, devoted especially to the machinery of railroads, and addressed chiefly to the master mechanics, and the more intelligent operatives. The next year he enlarged the "Advocate," which soon reached a large circulation and great popularity, not only among railway mechanics, but among the profession at large. It is worthy of mention, as illustrating Mr. Colburn's extraordinary power of memory, that he kept no books for many months, but simply remembered when every subscription and advertisement fell due, and made no mistakes.

* Mr. Colburn strictly commenced his professional career at the age of 15, at the Lowell Machine Shop.

In the summer of 1855 Mr. Colburn thought he saw, in his large and favorable acquaintance with railroad men, the way to a fortune in the business of railroad supplies. He therefore sold the "Advocate" to Mr. A. L. Holley, then draftsman of the New York Locomotive Works, bought land warrants with the money, journeyed to Iowa and located his lands, and then returned to New York—but with another scheme. The frontier life had temporarily charmed him, and he got together an engine and machinery to set up a steam sawmill in the far West. But before his plans were completed, literature and civilization had resumed the mastery, and he fell to writing for the "Advocate," because he could not help writing, and to arranging his supply business. The first thing—and the last—that he undertook in this direction was Ames's tiers, and with his knowledge, industry, shrewdness, and his advantages with the professional press, he kept the hammers at Falls Village busy day and night building up an immense business, which, unfortunately, the character of the tiers did not maintain.

But Colburn was not made for a merchant. He pined for larger professional observation and knowledge, and for a wider field. As suddenly as he went into trade he left it, and sailed for Europe. During a three months' stay or rather rush among the machine and iron works of England and France, whereof the story is recorded in the "Advocate," and is of permanent value, he had become again and finally wedded to literature. Returning to New York, he connected himself again with the "Advocate," which was then enlarged and entitled the "American Engineer."

In the autumn of 1857, Messrs. Colburn and Holley were commissioned by several leading railroad presidents to visit Europe to report on the railway system and machinery abroad, and in view of the financial troubles of 1857, they were advised to stop, at least temporarily, the publication of their paper.

Permanent-way and coal-burning locomotives were found to be the most important subjects of the period, and in 1858 their report on these subjects, largely illustrated by engravings, was published and generally circulated among American railway managers.

Mr. Colburn's thorough and, to American readers, entirely new and startling analysis of the cost and economy of British railways, was the foundation of many of the reforms that have since, although slowly, become standard here, especially in the matter of improved road-bed and superstructure. The success of this book was such that its authors determined to continue their researches, and in the fall of 1858, Mr. Colburn again visited London. Here he commenced writing for the "Engineer," then the leading professional journal, and soon became its editor. Under his vigorous management it largely increased in circulation and influence.

Mr. Colburn at this time wrote a supplement on the American Practice for a new edition of Mr. D. K. Clark's work on the "Locomotive Engine." After several years' hard work in London, Mr. Colburn resolved to start another engineering paper in America. He came out in the Great Eastern, on her first passage in 1860, and soon selected Philadelphia, the principal seat of mechanical engineering in this country, as the birthplace of his own "Engineer." It was an excellent paper, and the few numbers published will have permanent value; but the time was not ripe, in America, for a publication of this kind, and Colburn, although he had learned to labor, had never learned to wait. In a moment of despondency he dropped his new enterprise, sailed for England, and again became the editor of the London "Engineer." At this time he familiarized himself with the French language and professional literature. He also wrote several pamphlets on boiler explosions, heat, etc., the originality of which attracted great attention, and he commenced his great work on the locomotive engine.

In 1866, Mr. Colburn started in London the publication of "Engineering," which is in all countries accounted the ablest and best serial publication on that subject, and he dissolved his connection with it only a few weeks before his death.

During his residence in London, Mr. Colburn was employed as consulting engineer on many important constructions, and prepared many valuable papers in addition to his editorial labors. The more noted of these were his papers before the Institution of Civil Engineers (of which he was a member) on "Iron Bridges" and on "American Locomotives and Rolling Stock," both of which received medals.

Mr. Colburn wrote vigorously, originally, and with understanding on all the leading subjects embraced under the head of engineering. On the locomotive, the steam-engine and boiler at large, steam navigation, bridges, railway works, and mechanical engineering in general, he was a first-rate authority.

The saddest part of Mr. Colburn's story remains to be told. Overwork was at least a powerful agency in his early fall, and this, together with his natural impulsiveness and his habitual irregularity in relaxation, as well as in work, drove him within a few months into partial insanity. He came to this country a fortnight since, avoided all his old friends, strayed away to a country town in Massachusetts, and there died by his own hand.

Zerah Colburn was a man whom the profession could ill afford to lose. His thoroughly practical education in the work-shop, his extended observation of engineering works, his intimate acquaintance with professional literature, his remarkable quickness of comprehension, his more remarkable memory, and his mechanical talent and inborn engineering ideas, combined to give him a distinction that no engineer in the world will deny him—the best general writer in his profession.

IRON AND STEEL NOTES.

Railroad Iron.—"If iron has done so much for us as a nation, and must continue to do for us, at the rate of $600,000,000, in 1900 A. D., have we done our duty to it? Certainly not; for we are making our iron much inferior to that made before this great development, and make it from the best ore in the world. We are growing poorer yearly, even if the quality of our iron remain the same, as we exact greater burdens from it than it can bear, caused by the development of the country over a larger area, which demands higher rates of speed and heavier and longer trains on all our railroads.

We now know that we have laid in the 52,500 miles of railroad 4,725,000 tons, which every ten years must be re-rolled, based on English railroads

(but when based on some of the best railroads in the United States, every four years, based on five years' experience), which (472,500 tons annually) at $75 per ton is $35,000,000, and that this ten per cent. is worn and

By oxidation lost	$3,500,000
And a further cost in car wheels of	1,250,000
And will lose, to re-roll, some $25 per ton	11,812,125
Annual loss to the railroads	$16,562,125

This loss in car wheels is based on their lasting 5 years instead of 2-31, as they do on New York roads, viz., passenger, 1-58; freight, 3-01; and they carry a weight per wheel: passenger, 3¼ tons; freight 1-47 tons, and allow one half for old wheels. In 1900 A. D., the annual loss will be threefold, $16,562,125—based on population—and will double that, based on production of other articles of iron, making a total loss of wear of iron to the nation of between $100,000,000 and $200,000,000 annually. And this loss is made when we own the best ore in the world, caused by several reasons, chiefly by the purchasers demanding a cheap iron, not knowing the value of iron, excepting as based on price, and the competition of the manufacturers againts each other.—*Commercial Bulletin.*

Iron and Steel.—The following statement exhibits the quantities of the various kinds of iron and steel exported from Great Britain to the United States, during the two months ended February 28th, of the years 1869 and 1870, in tons of 2,000 lbs.

	1869.	1870.
Iron, pig and puddled	13,814	19,746
" bar, angle. bold, and rod	9,480	7,125
" railroad of all sorts	47,443	64,475
" castings	22	109
" hoops, sheets, and boiler plates	6,374	5,023
" wrought, of all sorts	1,830	1,745
Total	78,963	98,223
Steel, unwrought	2,677	1,680

American Railroad Iron.—The progress during the last sixteen years, in the production of American railroad iron, is indicated in the following table :

Year.	Tons.	Year.	Tons.
1854	108,000	1862	213,000
1855	138,000	1863	275,000
1856	180,000	1864	335,000
1857	161,000	1865	356,000
1858	163,000	1866	430,000
1859	195,000	1867	462,000
1860	205,000	1868	506,000
1861	189,000	1869	580,000

The production would thus appear to have increased last year to the extent of about 74,000 tons, while the increase in the foreign supplies did not exceed 35,000 tons. These totals are, to some extent, of an approximate character, but still they may be accepted as substantially correct. They show that the Americans are themselves making great exertions to keep pace with the American demand for railway iron ; and if we compare the total American production of 1859 with that effected last year, we shall see that enormous strides have indeed been made. Nevertheless, the area of the United States is so enormous, and the field opened out for American railway enterprise is so vast—27,505 miles of line being either projected or in progress at the commencement of this year—that it seems difficult to suppose that the Americans will find it practicable for a considerably further period to dispense with European supplies of railway iron. The question is one of much interest to the English iron trade, but still it is not of overwhelming importance. Thus, while the exports of railway iron from Great Britain in the first eleven months of last year showed an increase, as compared with the corresponding period of 1868, of 300,325 tons, 29,519 tons only arose under the head of exports to the United States.—*The Colliery Guardian.*

RAILWAY NOTES.

Narrow Gauge Railway.—We gladly insert at a late moment for the present issue the following brief extract from a letter giving some account of successful working of a narrow-gauge railway at the Thomas Iron Works at Hokendauqua, Pa. The line was built to take away the cinders from the blast furnaces :

"The road is 2 ft. 6 in. gauge, and is the same as when we used horse-power. The engines were built by Messrs. M. Baud & Co., at the Baldwin Locomotive Works, in Philadelphia. The steam-cylinders are 9 in. diameter and 12 in. stroke ; driving wheels 30 in. diameter with steel tiers 2 in. thick. In order to economize in room, we ascend very rapidly to the tip or dump, and a portion of the road has a gradient of 4 ft. in 100 ft., or 211 ft. per mile. Our cinder cars are four-wheeled, weighing when loaded 3 tons 5 cwt. gross ; wheels only 16 in. diameter. The engines weigh, when ready for work with tank full of water, 8 tons. 4 cwt. gross. One of them will haul with ease up this gradient of 211 ft. per mile, 8 of the cinder cars, making an aggregate of 26 tons, and that with a boiler pressure of only 120 to 125 lbs. per square inch.

American Railways.—It appears that the addition to the railway system of the United States during the past year was 6,588 miles, a total nearly twice as large as in any previous year. The first railway in America was commenced with 3 miles at Quincy, Massachusetts, in 1827, and the total length is now 48,860 miles, while there are 27,507 miles projected and in progress. The State with the greatest mileage is Illinois, which figures for 7,186 miles, and is followed by Pennsylvania with 6,878, Indiana with 5,331, New York with 4,735 and Ohio with 4,613. California has already 2,307 miles, and is far above some of the older States, such as Louisiana and Mississippi. The State with the least mileage is, of course, the small one of Rhode Island, which figures only for 131 miles. This account of length of roads does not include the second tracks with which most of the leading lines are supplied, nor the sidings and turn-outs. These may be estimated at 25 per cent. of the length of road, and are being added to yearly. Adding these supplementary tracks to the tabulated mileage, the total length of equivalent single track in use is about 60,000 miles, and adding to this the equivalent for the city passenger tracks, to nearly

65,000 miles. As regards works in hand it is stated that the new year opened with nearly 300 railroads in process of construction between Maine and California. These, it is estimated, when finished, will represent an aggregate of about 15,000 miles, and great efforts will be made to complete them all within the twelvemonth. Assuming the cost of building and equipment at $40,000 per mile, the expenditure will be six hundred millions of dollars for the year 1870. "These figures," it is remarked, "are certainly startling, and may create in the minds of many a fear that the business may be overdone. In years past it was the custom to civilize and populate a section, and afterwards build railroads. But we see this principle entirely reversed. We now build railways and let the country grow up to them.—*Engineering*.

THE BELGIAN STATE RAILWAYS AND TELEGRAPHS.—A paper on the passenger traffic of the State railways in Belgium, with remarks on the telegraphic system, by M. Corr-Vander Maeren, was read and discussed at the last meeting of the Social Science Association. From the statistics quoted in this paper, it appears that the total of the lines in working at the beginning of 1869, in Belgium, was in length 2,730 kilometres, or 546 leagues (about 1,640 English miles), divided as follows:

	Kilometres.
Worked by the State	862
Worked by companies	1,868
Together	2,730

The amount of the capital which the Government had expended for the construction of railways up to January 1, 1868, was together 262½ millions of francs (about 10½ millions of English pounds sterling).

The cost of construction of the State railways amounts to 409,647 francs (about £16,400 per kilometre (or five-eighths of an English mile), divided as follows:

	Francs.
Railway (the cost of the lines)	236,424
Buildings, stations, etc	67,763
General expenses	8,665
Rolling stock	96,795
Total cost per kilometre	409,647

Or at a cost of £26,200 per English mile.

The general result of the working for the year 1858, is as follows:

	Francs.
Total receipts	38,318,509
Total working expenses	24,826,964
Surplus	13,491,545

Or about £540,000.

These 13½ millions of francs profit upon the workings of 1868 give 5⅛ per cent. upon the whole capital expended upon the railways (say upon 262½ millions of francs).

These figures show that the railways, which have done so much for the country, both in a political and economic point of view, have not only been self-sustaining, but that their general pecuniary result is a profit since their origin of nearly 57,000,000 francs, about £2,280,000, including interest on loans, sinking-fund, and all incidental expenses.

The lowest rates of tariff have been found to be the most productive. The differential fares introduced by the decree of the 20th March, 1866, and now operative, instead of the *fixed* rates of 8, 6, and 4 centimes per kilometre, substituted upon the bases of those rates a system of reduction, decreasing the rates with increased distances. The fares, however, are not so low as they once were, neither are they so profitable. The telegraph in Belgium is, like the post-office and the principal lines of railway, worked by the Government under the direction of the Minister of Public Works. The tariff established by the State at the onset was calculated, by dividing the country into three radii, zones, or different distances, fixing the rates respectively at 2f. 50c., and 5f., and 7f. 50c. for 20 words (2s., 4s., and 6s.).

As the use of the telegraph increased, the tariff was reduced time after time, until the 1st of December, 1865, when the uniform rate of 50 centimes (about 5d.) for the whole of the country was introduced and carried out with great vigor and success. Previously to the 1st of December, 1865, the rate for simple telegrams of 20 words was 1 franc. This was for telegrams of the interior of Belgium.

The telegraph in Belgium has long since completely paid off the entire expenses of its first establishment. Beyond that it shows, on the 1st January, 1869, in the general account, a net profit of about 700,000 francs (£28,000).—*The Builder*.

PULLMAN'S LAST.—The Pullman Palace Car Company is not entirely absorbed by the occupation of new lines. Having absorbed the Central Transportation Company and thus extended its attractions to travellers to a few thousand miles of road, and also the Southern Transportation Company, which has run its cars on 1,500 miles of road in the South and South-east, it introduces a novelty which is likely to make travelling by rail for pleasure more popular and much more desirable than it has ever been before. This is done by means of a car called a "Portable Hotel," which is fitted up in the most elegant manner with state-rooms, parlor, and kitchen, so that a small party—about twenty—may live in it as in a hotel, having in one car just about the accommodations travellers now can get only with two, a drawing-room and sleeping car and a hotel car. But the novelty is rather in the use of the cars than in their construction. It is proposed to let them to parties who will pay for them by the day and travel in them where they please, and stop as often and as long as they please, wherever they please, on any road where Pullman cars run—that is, on most of the great through routes of the North and East. The rent of a car is about $85 a day, and that includes its transportation on passenger and express trains, and the regular complement of servants, including steward, cook, and waiters. The only other expenses are those for catering. This could be done as well as at first-class hotels for $2 a day. Thus a party of 20 could travel at an expense of $6 a day, carrying their hotel with them, living and lodging in the car during their halts as well as while moving. In this way the civilized world may be seen without trouble at comparatively small expense. We anticipate for this latest and most attractive of Pullman's inventions a wonderful popularity. The first trial is made by Mr. Pullman and a party of his friends, who started last Thursday on a tour which is to extend to New Orleans, New York, and back to Chicago.—*Western Railway Gazette*.

THE NEW TURKISH RAILWAY undertaking is to be called the Societe Imperiale des Chemins de Fer de la Turquie d'Europe, and it will issue 750,000 obligations, for which subscriptions will be opened on the 15th inst. at Constantinople, Alexandria, Bucharest, Vienna, Berlin, Amsterdam, Hamburg, Frankfort, Trieste, Lemberg, Prague, Leipsic, Dresden, Munich, Geneva, Berne, Zurich, Milan, Florence, and Naples. These obligations are each for 400f., bearing interest at the rate of 3 per cent. per annum, with the advantage of lottery drawings with large prizes six times a year, including three of 600,000f. and three of 300,000f. each, besides many smaller ones. The price is fixed at 180f., and the lottery redemptions will be at par (400f.). A public issue cannot be made either in Paris or London, on account of the lottery, but it is is said that the French Government look upon the operation with much favor on account of the political importance of railway communication in giving stability to Turkey, and this feeling will be shared in England. The works are to be commenced at once from each end—the frontier of the Austro-Hungarian empire on one side, and Constantinople to Adrianople on the other.

SWITCHING-ENGINES WITH WATER-TANK FRAMES.—In Great Britain and Germany there have recently been constructed a number of locomotive engines for switching purposes, whose chief peculiarity consists in their having the frames which support the boiler and machinery made of wrought-iron plates, very much on the same principle that wrought-iron box tubular bridges are made. These frames are made water-tight, and are used to carry the water required by the engine. These engines rest entirely on two small driving-wheels placed between the forward part of the fire-box and the hind part of the smoke-box, and this arrangement of the water-tanks is not only compact, but useful in causing an even distribution of weight on the driving-wheels, they being extended well forward, thus balancing the weight of the fire-box. The frames fit closely to the boiler, but are so arranged as not to interfere with its being lifted out when necessary.

THE NORTH-EASTERN RAILWAY OF SWITZERLAND is certainly more successful than most English lines. According to the latest published returns, it appears that the entire capital raised for the construction of the railway and the purchase of two branch lines amounts to 66,808,000 f. (£2,672,320) for an entire mileage of 164 miles, the greater portion of which—namely, from Aarau to Zurich, and thence to the Lake of Constance—has double rails. Of the capital, two-fifths was raised by ordinary shares, and the remainder by obligations bearing a fixed rate of interest, in part guaranteed by the various cantons and in part by the company itself. In 1868 the gross receipts were £295,269, and the net profits, after paying all expenses, £167,555. In this, however, are included the profits realized by the steamboats of the Lake of Constance, which figures for nearly £9,000. The dividend distributed among the shareholders was at the rate of 8 per cent., somewhat in excess of that of any previous year.

THE addition to the railway system of the United States during the past year was 6,588 miles, a total nearly twice as large as in any previous year.

ORDNANCE AND NAVAL NOTES.

THE iron shipbuilding trade at Hull is in a more active condition than for some years, several steamers of very large tonnage being in course of construction, while others are fitting out in the dock. One of the finest steamers ever built at Hull has just been completed.—viz., the Orlando, built by Messrs. C. and W. Earle for Messrs. Wilson, Sons, & Company. Messrs. Wilson have a contract with the Swedish Government for the conveyance of the Swedish mails, and the Orlando is intended for that service, and for the accommodation of the ever-increasing number of tourists to Sweeden.

The Orlando was put upon her trial trip on Friday, and although she was too light to be in good trim she steamed about 12½ knots an hour. She is 260 ft. long. 34 ft. wide, and is 1,400 tons gross. She is fitted with compound engines 38 in. and 76 in. in diameter, 36 in. stroke, and combining all the latest improvements, surface condensation, expansion valves, and everything to insure economy of fuel and speed. Her engines are of 250-horse power and indicated on trial 850-horse power; pressure, 60lbs.; vacuum, 28lbs.; revolutions, 59. The passenger accommodation on board is as follows: Saloon 50; second cabin 32; steerage, or emigrant accommodation, 800. The saloon is amidships, the second cabin aft, and the accommodation for emigrants on the main and lower decks, both of which are lofty and well ventilated. This excellent provision for passengers will make the Orlando one of the most suitable vessels afloat for the transport of troops should occasion arise for her employment in this service.—*Mechanics' Magazine*.

THE PRUSSIAN ARMY.—The "Revue des Deux Mondes" has an article on the state of the Prussian forces at the present time. According to the writer (who, however, is believed to be *not* the person whose signature is attached to the article), the Prussian army consists of: First, the actual army, numbering on its peace footing 140,000 men, but capable of being increased in a few days to 220,000. Second, the first ban of the Landwehr—cavalry and infantry—composed in time of peace of about 3,000 men, the *personnel* only of the various regiments, but numbering on the first summons to arms upwards of 150,000 men. Third, the second ban of the Landwehr, numbering about 110,000 soldiers. This last class comprises all those who under the old system formed the Landsturm, which included all persons between the ages of 17 and 49 capable of bearing arms who are not included in either of the preceding categories. It appears, moreover, from this article, that while the effective strength of the Prussian army has been rapidly increased, its expenditure has, by the introduction of the short-service system, been considerably diminished. In 1820 the average cost of each Prussian soldier was 211 thalers (£31 13s.); in 1859, 214 thalers (£32 2s.); and in 1869, only 196 thalers (£29 8s.) From these figures it is evident that Prussia is actually making a considerable profit out of the contingents furnished by the various States which make up the North German Confederation; for Article 62 of the Constitution allots to the Generalissimo of the Forces (the King of Prussia) a round sum of 225 thalers (£33 15s.), payable out of the revenues of each State, for every soldier furnished to the

Federal forces, while the number of each contingent is fixed at one per cent. of the population in time of peace. The Federal army, on its peace footing for the ensuing year, will consist of 319, 000 men.

THE IRON DUKE, a magnificent specimen of naval architecture, was successfully launched from Pembroke yard. This ship is built wholly of iron, and she is furthermore armor-plated with iron slabs, 8 in. thick, down to the water-line. She is a very fine model, and it is fully anticipated that she will attain the speed estimated—namely, 13½ knots—being propelled by twin-screws, driven by first-class engines of 800-horse power, on the trunk principle. Her armament will consist of fourteen 9 in. guns, twelve tons each, so that taking this into consideration, together with her armor and the immense speed anticipated from her, she will undoubtedly prove a most formidable antagonist. Her accommodation for officers and crew is excellent. The between-decks are about 10 ft., thus insuring, with other appliances, good ventilation.

NAVIGATION.—The experimental brig Novelty, constructed simply as iron tank, to hold molasses in bulk, which arrived in Boston from Matanzas, discharged her cargo of 88,000 gallons, by means of pumps and hose, direct into the reservoir of a refinery, was refilled with Cochituate water, shipped a new crew, got ready for sea, and departed within 27 hours from the time of her arrival. There is no room, says the New York "Tribune," to doubt the immense improvement of this mode of transporting molasses.—*Iron Age.*

THE RUSSIAN FORCES.—The "Invalid," organ of the War Office at St. Petersburg, gives us a sketch of the state of the Czar's forces. This year the active Army consists of 726,000 men, or about 10 per cent. of the population capable of furnishing recruits, in which are not comprised the people of Finland, the Caucasus, Central Asia, parts of Siberia, and the Cossacks. The reserve has been considerably augmented. In 1865 it numbered 190,000 men ; in 1866, 333,000 ; in 1867, 410,000 ; in 1868, 460,000 ; in 1869, 511,000 ; and in a few months' time it will reach 553,000 men, all, says the "Invalid," well drilled ! As the strength of the reserve on a war footing should only reach to 430,000 men, the War Minister has a handsome surplus in hand, and appears as proud of it as a Chancellor of the Exchequer who has managed to save a few millions. To this active army and reserve must be added the Cossacks, who furnish in time of war 133 regiments of cavalry, 24 battalions, and 200 guns ; in all 300,000 men, which is very respectable as an additional force. The new armament of the Russian Army will be terminated, we are told, about the 1st April next, when Russia will possess 965,000 breech-loaders ; 622,000 being on the Krok, 60,000 on the Berdan, and the remainder on the Karl and Baranow systems. The Navy is armed with Baranow rifles. There are manufactories of arms at Zoula, Zjew, Lestroretsk, Tiflis, Warsaw, Kiew, St. Petersburg, etc., and in the capital three factories turn out half a million of metallic cartridges per diem. All the field batteries are furnished with guns on a new system, even those of the Cossack corps. There are more than 1,200 of these pieces, without counting 90 mitrailleuses, whose number is to be considerably augmented. The fortresses possess 1,000 improved guns, all cast in Russia, with the exception of the large pieces from Krupp. Thanks to a wise Administration, says the "Invalid," all these changes have been effected in a most economical manner, and in the matter of discipline there is nothing to complain of. It is well to remember, adds the organ of the War-office, that the law of March, 1869, in admitting sub-officers to the schools of ensigns opens up to them the grade of officer. No wonder that this immense force requires new strategic railways, and a loan to make them.—*Army and Navy Gazette.*

ENGINEERING STRUCTURES.

THE GREAT UNION DEPOT ON FOURTH AVENUE, NEW YORK.—The contract for this enormous structure has been finally awarded to the Architectural Iron Works at the foot of Fourteenth street, New York. The depot is intended to accommodate the trains of the Harlem, Hudson River, and New York Central Railroads. For the latter a branch road will be built to connect with the Harlem, the trains being switched off in the neighborhood of Spuyten Duyvil. The car-house will have accommodations for 12 single trains, while, if it be necessary, double or even treble that number can be accommodated.

Photographs of the plans and drawings were sent to Europe for bids, but it was found that American foundrymen could more than compete with any bids received abroad.

The foundation of this immense structure, to be the largest of the kind on this continent, is well under way—in fact, nearly completed. The contract calls for the completion of the entire structure within 8 months from its date. If not completed within the time specified, the contractor is to forfeit and have deducted from the contract price $500 a day for every day over ; and if completed within the time specified, the contractor is to receive, in addition to the contract price, the sum of $200 for each day the work is so completed and accepted by the engineer.

The weight of iron to be used will be over 8,000,000 lbs. It will require 100,000 square ft. of glass in the roof alone, and 90,000 square ft. of galvanized corrugated iron to cover the roof. The roof over the car-house will extend over an area limited south and west by the office buildings, east by the Fourth avenue, and north by a line 30 ft. 6 in. south of Forty-fifth street. The entire length of the roof will be 652 ft., and it will be 199 ft. 2 in. in width between the walls, and supported by 32 arched trusses placed 20 ft. 4 in. apart. These great arches will be set upon the foundation, whose upper face is 2 ft. below the surface of the ground, rising to an elevation of 94 ft. from the springing line to the extrados of the arch.

The car-house is to be lighted through 3 skylights extending over the entire length of the roof—1 on the centre, double pitched, and 2 single ones on each side of the centre. There will be 7 courses of ventilators running the entire length of the roof, faced up with stationary sheet-iron slats. On the south end, the segmental portion of the arch above the brick wall will be faced with cast-iron trimmings and plate glass.

The north end will be closed with a beautiful cast-iron front highly ornamented. The east side,

along the Fourth avenue, will be finished with cast iron pilasters acting as casings set in front of each truss. These pilasters are to have bases and caps, supporting a main cornice along the front, and crowned by a cast-iron balustrade; a line of balconies will run along the west side and across the south end, connecting with the offices in the second story. The trusses are placed in heavy cast-iron shoes, 64 in number, To permit free expansion and contraction of the trusses, without interference with the side walls crossed by them, there will be placed cast-iron boxes or casings perforated by a series of cores, and fitted together by means of bars and angles in such a manner as to insulate entirely the mason work from the trusses.

The rafters will consist of 5-in. deck beams, secured to the top chord by double angle iron studs, $3\frac{1}{2}$ by $3\frac{1}{2}$ in., and stiffened by diagonal braces of same size; riveted together and fastened on the chord by means of bent lap plates $\frac{1}{2}$ in. thick, and riveted to the former.

The doors and windows will have cast-iron trimmings, all ornamented, the windows to be glazed with rough $\frac{1}{2}$ in. glass. The whole of the north front will be of cast-iron, the width to be 203 ft. 10 in., and raised 112 ft. 6 in. extreme height. The windows and doors of the first story will have rolling shutters.

The ends of the structure will be occupied for offices on the first floor, while the ground floor will be set apart for ticket offices, passengers' rooms, baggage lockers, restaurants, news-stands, etc.

Pennsylvania iron of the best welded quality will be used for plates, flat or square bars. Round bars and rods for braces to be of Ulster iron; rivets and bolts of charcoal iron. Sheet iron, best welded and refined Pennsylvania. Cast-iron mixed in the following proportions, viz.: American pig No. 1, and Scotch pig No. 1, 5 per cent. of each for shoes, casings, lintels, box, angle, studs, and braces. American pig No. 1, 10 per cent., and Scotch pig No. 1, 15 per cent., for columns and pilasters. American pig No. 1, 15 per cent., and Scotch pig No. 1, 20 per cent., for hanging cornices, friezes, and flat panellings. American pig No. 1, 30 per cent., and Scotch pig No. 1, 30 per cent., for small mouldings and ornamented work. All rolled and welded iron to be subject to a strain of 30,000 lbs. per sectional inch.—*Scientific American.*

GOOD TUNNELLING.—A great underground work is the Ernst August Gallery—one of five belonging to a metal mine in the Hartz. "The mouth of it is at Gittelda, in Brunswick. It is 10 ft. high, $6\frac{1}{2}$ ft. wide, and has a fall three-fifths of an inch in a yard. Like a railway tunnel (but it is twice the length of the longest), it was begun simultaneously at various different points, and finished in 13 years. The gallery is $6\frac{3}{4}$ miles in direct length; but if its lateral branches are taken into account, and a subterranean gallery, navigable for boats, which opens into it, the Ernst August Galleries are said to be not less than 15 miles long. All the junctions of the different sections fit accurately into each other, the precision of the results having been partly insured by the aid of a magnet, weighing 200 lbs., which influenced the compass through the solid rock 65 feet deep, and which was kept in one of the working-places, while the compass was held in the other.—*The Builder.*

NEW SUSPENSION BRIDGE IN TEXAS.—The new suspension bridge at Waco, Texas, is a work of great importance to the South-west. It is on the main line of travel from Memphis and the Red River, through Central Texas, to the Rio Grande.

It is a suspension bridge of 475 ft. span, 18 ft. wide. The towers are of brick; the foundations are upon rock on on side and quicksand upon the other.

The iron work was constructed in New York, and the entire amount of wood work was hauled 80 miles by ox teams.

A pile-driving machine was improvised by the engineer, the hammer being of live oak, banded with iron from old wagon axles.

The pumping inside of the coffer-dams was done by a force of negroes, using log pumps.

Waco is about 300 miles from Galveston. The engineer is Mr. Thomas M. Griffith.

THE CHANNEL BRIDGE.—SIR: I am tempted to trespass on your valuable space in order to correct some misapprehension on this subject, by the spirit of impartiality which has been shown by your journal on the subject of the various plans proposed for crossing the Channel. You have, I believe, expressed an opinion that a bridge, if it could be made, would be the best plan, as it would be the most natural, and the safest and most agreeable for public use.

It is unfortunate that the exceeding interest which attaches to the subject generally, and the important character of the steps which have been taken towards ascertaining the practicability of M. Boutet's bridge, which Captain Tyler, in his report to the Government on the subject, stated was the one which had made most progress, have led the papers to discuss it before the author is prepared to make it public. It has, however, been recently stated that his proposal is for a bridge on 190 piers, costing 30 millions, instead of which it is to have 29 piers only, and to cost but 8 millions. It has also been said that there are no English subscribers to it, and that French engineers deem it unworthy of notice. I am proud to say I am an English subscriber; and I was present at the meeting held in Paris on the completion of the 66 ft. model, at which English subscribers attended, and proxies were produced from others who could not attend. French engineers were there and addressed the meeting, and I met afterwards engineers of eminence in Paris who spoke favorably of it. Notably General Fair, the director of Ecole Polytechnic at Paris, and the engineer of the Montmorency Railway; and it was stated by the President at the meeting, Comte Cardaillac, who is at the head of one of the departments of the French Government, that a commission of French Engineers, whom the Emperor had met to examine the plan for his private satisfaction, had reported favorably upon it, and that the Emperor was in consequence prepared to order a bridge of 100 metres to be built on M. Boutet's system, which is now in progress, and bids fair to rival its predecessors in interest and importance, and be as great a success as every other step in this matter has been. The best proof of this is that those who have subscribed towards the work are satisfied with the progress which has been made, and look forward with confidence to the successful development of the system which is in contemplation.

M. Boutet has been blamed for not having made

his plan more public, but I think he is to be commended for desiring to ascertain first the efficiency and powers of his system. I am, sir, yours, &c.,

LONDON, *March* 22. FAIRPLAY.

—*Mechanic's Magazine.*

THE Russian Government is making a very important experiment. The Exas now flows into the Sea of Aral. It once flowed into the Caspian, its old bed being still visible enough to be a feature in maps. If it could be brought back, the Russians would have an unbroken and impregnable water communication from the Baltic to the heart of Khiva, and, with further improvements to Boekh, would, in fact, be able to ship stores at Cronstadt for Central Asia, and send them without land carriage. The addition to their power would be enormous; and their engineers think it can be secured. An energetic officer, with eighteen hundred men, is already on the south bank of the Caspian; the natives are reported friendly, and the Russian Government has the means, through its penal regiments, of employing forced labor on a great scale.

THE WATER SUPPLY OF SYDNEY.—The commission appointed to inquire into the best means of supplying Sydney and its suburbs with water, have lately submitted their report to Parliament. Their labors have extended over a period of two years. In their report they have given the outlines of a scheme which seemed to them, on the whole, to be superior to all others examined, and they therefore agreed to recommend its adoption—the scheme, namely, of bringing down the waters of the higher affluents of the river Nepean by gravitation. The catchment area is 354 square miles in extent, the rivers that drain the selected district take their rise mostly in swampy flats between 1,200 and 1,600 ft. above the sea; but at the confluence of the Corbeaux with the Nepean, where it is proposed to make the first interception of the waters, the height is 430 ft. In regard to extent of surface, purity of water, freedom from sources of contamination, want of value in the lands for other purposes, and altitude above the sea, the commission consider that there is in this scheme all that can be desired; the great drawback is the distance from Sydney (63 miles measured along the proposed conduit), which, though not important in an engineering point of view, will necessarily be a source of great expense. Instead of constructing dams, it is proposed to construct one large reservoir apart from the river, where they would not be subject to floods. Good sites for reservoirs have been found near Prospect, 21 miles from Sydney. It is proposed to convey the waters to Prospect by means of canals, tunnels, and raised aqueducts. Two methods for bringing the water from Prospect to Sydney have been considered by the commission. First, a high level scheme, by which the water would be impounded at a maximum height of 260 ft., in a large reservoir, with a possible additional height of 20 ft. by means of a small reservoir higher up—the water to be brought down to Sydney (a distance of 21 miles) in pipes. And, second, a low level scheme, by which a larger body of water would be impounded at a maximum height of 195 ft., and be brought to Sydney by 8 miles of open conduit, and 13 miles of pipes. It was estimated that the high level scheme would cost £1,046,846, and the low level, £790,029. After prolonged deliberation the commission agreed to recommend the low service scheme for adoption. In concluding their able report (which was a very lengthy one) the commission point out reasons for believing that costly as the work would be, it might be made productive.—*The Artizan.*

NEW BOOKS.

HAND-BOOK OF THE STEAM ENGINE, containing all the rules required for the right construction and easy management of engines of every class, with the easy arithmetical solution of those rules. Constituting a key to the Catechism of the Steam-Engine. Illustrated by sixty-seven woodcuts and numerous tables and examples. By JOHN BOURNE, C. E. New edition. Philadelphia: J. B. Lippincott & Co. For sale by Van Nostrand.

That this excellent work has reached a third edition is some evidence that its merits are appreciated, and that it supplies a want among rising engineers.

Young mechanics find in it an efficient supplement to the theoretic knowledge obtained at the day or night school.

Practical engineers use it as a good compendium of the rules for engine construction and management.

CYCLOPÆDIC SCIENCE SIMPLIFIED. By J. H. PEPPER, Professor of Chemistry in the Royal Polytechnic Institution. London: Frederick Warne & Co. New York; Scribner, Welford & Co. For sale by Van Nostrand.

This is, without doubt, the most complete compendium of experiments in physical science, in the English language.

The several divisions of the work are given under the heads of: light, heat, electricity, magnetism, pneumatics, acoustics, and chemistry.

There are 540 illustrations, many of which, illustrating lecture-room manipulations, are so skilfully designed as almost to render the descriptive text unnecessary.

A MANUAL OF QUALITATIVE ANALYSIS. By ROBERT GALLOWAY, F. C. S., Professor of Applied Chemistry in the Royal College of Science for Ireland. Fifth Edition. London: John Churchill & Sons. 1870. For sale by Van Nostrand.

This treatise on chemical analysis, through the care of its author to make it accurate and to adapt it to the wants of the earnest student, has long been established as one of the best in our language. It was at one time a distinguishing character of this work, that in it the art of chemical analysis is taught by first giving appropriate exercises, and then helping the student to deduce from these the principles and rules of the art. In other treatises, the student was first carried through a sort of grammar, and then taught the application of this to the execution of the purposes of the art. Now, however, Professor Galloway's *Qualitative Analysis* does not possess this distinctive character, for the simple reason that in most of its fellow-treatises the same principle has been more or less fully adopted, though in none so thoroughly as in it.

In its present edition it forms a much more comprehensive work than in the previous ones. As it now stands, it includes, besides other matter,

a very full descriptive account of the more important and best-known substances, in which their chemical properties are compared and contrasted in a very useful manner. And it seems to us, after an examination of its pages, that no method of learning chemistry would prove so successful as that of working out such a practical course as that laid down in it, and at the same time attending a *few* lectures on the doctrines of the science.

In addition to the account of salts and acids, together with their radicals, to be expected in such a work, descriptions, to be verified by experiment, are given of almost every "organic" substance of interest in medicine, physiology, toxicology, and the arts. The action of heat upon substances as a means of ascertaining their nature is elaborately detailed, the author availing himself of the papers of Bunsen and Merz upon the use of the Bunsen lamp as an instrument of analysis.

In the present edition Professor Galloway has adopted the modern notation and nomenclature, and, what is of more importance in a work on practical chemistry, he has added many tests to those given in the fourth edition. We consider it an omission of the author, and we have observed no other worth notice, not to have given an account of Bunsen's admirable, quick, and thorough filtering apparatus. Probably he thought it adapted for quantitative rather than for qualitative experiments; but, if so, we are hardly prepared to agree with him. Of all things most calculated to dishearten the student of qualitative analysis, the filtration and washing of slimy precipitates rank first, and therefore, to deprive them of their tedious character is to confer a very great boon on the student, and to favor the cultivation of chemistry itself.—*From Scientific Opinion.*

A NEW SYSTEM OF VENTILATION. By HENRY A. GOUGE. 8vo, 176 pp. New York: D. Van Nostrand, 1870.

It is related of Faraday that he one day tried some experiments on the purity of the Thames water in London, by sinking bits of white paper. The next day he wrote a letter on the subject to the London "Times." This letter had more to do in calling attention to the dangerous sewage system of the city than anything that had appeared from any other source, and eventually led to the expenditure of millions of dollars in the construction of the great Thames embankment, for rectifying the evil. We want a second Faraday to arise in this country, and warn the people of the danger of neglect of ventilation. The author of the book, the title of which we have just given, shows how necessary fresh air is to health, and he gives startling examples of the ill consequences of a neglect of the rules upon this subject. He has a somewhat original way of presenting his claims, but if he can accomplish his object he will be doing a good work. The quotations from some of our most distinguished writers are much to the point, and add to the interest of the book.—*Journal of Applied Chemistry.*

BIBLIOTHEQUE DES MERVEILLES. Paris: L. Hachette & Co. For sale by Van Nostrand. In reviewing various English translations from French authors, that have of late been introduced among us, we have had occasion to refer to MM. Hachette, of Paris, as being the most useful and elegant of French publishers in the special branch of literature we are now alluding to. Such works as "La vie Souterraine, Les Voyages Aèriens", and others of the same class, are invaluable for the amount of information they contain, and the manner in which it is arranged for the capacity of the general reader. It is certain that accurate and artistic engravings convey more to many minds than a simple description, while no amount of technical language will be satisfactory to the uninitiated reader; a few strokes with the pencil often do better service than much hard labor with the pen, and information thus conveyed being more striking, is retained longer in the memory, than much technical description. In working upon this system, MM. Hachette have spared no pains in making their educational works perfect, and while such volumes as we have mentioned cannot, from their high cost, command a universal sale, a valuable and cheap series under the general title of "Bibliothèque des Merveilles," is in course of issue by the same publishers, which within narrower limits pursues the same object. Such is "Les Chemins de Fer," by M. A. Guillemin, a carefully written handbook, fully illustrated with drawings, which range from a navvy's pick and spade, to locomotives and rolling stock details, the object in view being to bring graphically before the reader, the nature of all necessary works, and the mode of carrying them out. It is not urged that such a work will be found of great service to the engineer, but it forms rather a means by which every one can make themselves acquainted with a subject of which they are generally ignorant.

Of the same nature is "L'Acoustique," a complete elementary text-book on the phenomena of sound, philosophical and historical, written throughout in a pleasant easy style. In addition to these we may add "La Fond de la Mer," "Les Armes et les Armures," by P. Lacomte, "Les Ascensions Célèbres, L'Eau," by M. Tisandier, and "L'Electricété," by M. J. Baillie. Such are a few volumes of the Library of Wonders of MM. Hachette, and we are glad to know that most of them are being reproduced here for the benefit of English readers. For the present we may content ourselver with this brief notice of the series, feeling assured that the publishers have conferred an international benefit in their production.—*Engineering.*

THE ELEMENTS OF BUILDING, CONSTRUCTION, AND ARCHITECTURAL DRAWING. With one hundred and thirty-three illustrations drawn on wood by the author. By ELLIS A. DAVIDSON, Science and Art Lecturer in the City of London Middle Class Schools, etc. London and New York: Cassell, Petter & Galpin. For sale by Van Nostrand.

This handy little volume is the third of a series of excellent technical annuals by the same author, which Messrs. Cassell have lately issued for the use of the student and the artisan. Although the book consists of but 120 small octavo pages, it contains a much greater amount of useful information relating to the subjects of which it treats than many works of far greater pretensions—a result which Mr. Davidson has attained by carefully avoiding all verbosity, and occupying the space at his disposal solely with clearly stated facts. Commencing with a chapter on the drawings required for building purposes, our author next treats of the general principles of building, construction, of foundations, natural and artificial, and of coffer-dams, caissons,

and similar appliances. Then come chapters on masonry and on brickwork, and these are followed by others on drawing for bricklayers; on woodworks; on the construction of roofs and floors; on partitions; on joinery; and on fire-proof construction. The information given on all these matters is excellent, the clearly written text being rendered still more clear by the numerous wood-cuts by which it is interspersed. This little manual is, in fact, the best work of the kind which we have seen, and in heartily recommending it to the classes for whom it was written, we may express a wish to see many other such books from the same pen.—*Engineering.*

The Science of Building. An elementary treatise on the principles of construction, especially adapted to the requirements of architectural students. By E. Wyndham Tarn, M. A. London: Lockwood & Co. For sale by Van Nostrand.

The separate chapters treat of—

1. Mechanical principles.
2. Retaining walls.
3. Arches and cupolas.
4. Building stones.
5. Timber.
6. Iron.
7. Water in vessels and pipes.

A scientific treatise, presenting topics of an advanced grade of technical art, but involving no higher mathematics than geometry and algebra.

Qualitative Chemical Analysis. By Dr. C. Remigius Fresenius. Seventh Edition. Edited by Arthur Vacher. London: John Churchill & Sons. 1870. For sale by Van Nostrand.

We doubt very much that an English chemist will be found in the present state of things who can write a work on chemical analysis equalling, both in exactness and minuteness of detail and in the originality of its contents, that which can be written by a German. At least in Germany we find chemists who are both able and willing to devote a lifetime to the developing and perfecting processes for the detection and quantitative estimation of substances, and are not very likely to find such men in England. We are led to express this opinion by having before us the new English editions of the two volumes of Fresenius on "Chemical Analysis." The Wiesbaden Professor is a pre-eminent instance of one who has devoted a lifetime to the object we have indicated. He has raised in these works monuments to the vast assistance he has afforded to other chemists in their labors, which will remain long after him, but which can never bring him that renown that an equal application of his abilities and time to other branches of his science would have done.

The treatises on Qualitative and Quantitative Analysis by Fresenius have for a great number of years been familiar to English students and teachers of chemistry in the excellent translations of Mr. Lloyd Bullock. They are now given to us by the hands of Mr. Arthur Vacher, who has not merely reproduced the substance of them, but has freely availed himself of his editorial capacity to make such modifications as he deemed improvements in them.

We cannot epitomize more briefly than the editor has done the differences between the sixth edition of the "Qualitative Analysis" and the seventh:

"Several improvements, necessitated by the progress of discovery, have been introduced by the author; and I have specially striven to meet the wants of English students. The language has been condensed, the notation and nomenclature have been modernized, the arrangement has been simplified. The consideration of rare inorganic bodies and of organic bodies has been deferred to the latter part of the volume, where a section has been devoted to each. The grouping of the metals has been harmonized with the course of analysis. The course of analysis has been simplified in description, and the preliminary examination has been curtailed. Analytical tables have been added at the end, which include the preliminary examination and the detection of metals in soluble mixtures."

The improvement is material in the arrangement for the analysis of mixtures of salts, most of the tiresome references to other pages having been avoided.

The section on the detection of the alkaloids continues to be an extremely valuable part of the work.—*From Scientific Opinion.*

The Second Course of Orthographic Projection; being a continuation of the new method of teaching the science of mechanical and engineering drawing; with some practical remarks on the teeth of wheels, the projection of shadows, principles of shading, and drawing from machinery. With numerous illustrations. By William Binns, Assoc. Inst. C. E. London: E. & F. N. Spon, Charing-cross. 1869. For sale by Van Nostrand.

After an interval of some years, Mr. Binns has supplemented his Elementary Treatise on Orthographic Projection with a second volume, in which he has compressed the pith of the lectures delivered by him at the late College for Civil Engineers, Putney, and at the Department of Science and Art, Kensington. In this second course of Orthographic Projection, he has propounded the importance of establishing a uniform system for the formation of the teeth of wheels, and having compared the various methods now in use, and slightly altered that which is considered the best among them, he hopes his improvement will be recognized and universally adopted, so that for the future there may be but one form. As matters now stand in this department of mechanical engineering, two wheels of any given pitch obtained from different makers will not work together, because every maker has a formula of his own for the shape of the teeth, which he believes to be the best, but which, as we have remarked, prevents his wheels from working with those obtained from any other firm. After describing the methods pursued by various engineers, including that obtained by the use of the odontograph, he lays down a plan, by the adoption of which the inconveniences attending the present diversity of rules might be done away with. He proposes:

"1. That there shall be a generating circle for every pitch, and that the pitch be stamped or otherwise marked on each 'scriber,' or generating circle.

"2. That the diameter of each generating circle be equal to the radius of the least wheel of the set.

"3. That the number of teeth assigned to the least wheel be fourteen for all sets of wheels for mill gearing."

The proposal of a universal epicycloidal system has been made before now, but from the fact of a

want of sufficiently definite terms it fell to the ground. The diameter of the scriber, for instance, was left to the judgment of each maker. Mr. Binns's more precisely stated proposal is likely to be useful. To those in want of plain instructions on orthographic projection, we commend the work, generally. The author, we perceive, particularly recommends to pattern-makers the section of it we first mentioned.—*The Builder.*

A Manual of the Chemical Examination of the Urine in Disease; with brief directions for the examination of the most common varieties of Urinary Calculi. By Austin Flint, Jr., M.D., Professor in Bellevue Hospital Medical College. 12mo., pp.76. New York: D. Appleton & Co., 1870.

This is a handy book for the use of physicians who may be called upon to make tests of urine. There is a list of all the reagents and apparatus required, and the latest methods both for qualitative and quantitative analysis of urine are concisely stated. The tables will be found convenient, and as they are printed on a separate sheet at the end of the book, they can be cut out and framed for immediate reference. The book is illustrated by good wood-cuts of apparatus, thus greatly adding to its value. We do not know of any work in English so complete and handy as the manual now offered to the profession by Dr. Flint, and the high scientific reputation of the author is a sufficient guarantee of the accuracy of all the directions given.—*Journal of Applied Chemistry.*

Causeries Scientifiques, Decouverts, et Inventions, Progres de la Science et de l'Industrie, etc. Par Henri de Parville. J. Rothschild, Paris. 12mo., with illustrations. For sale by Van Nostrand.

The ninth volume of M. de Parville's annual record of scientific and industrial novelties, always a welcome publication, not only on account of the matter itself, but also of the lucidity of the style, the liberality with which the text is illustrated by practical diagrams, as well as picturesque illustrations, and the clear type.

Amongst the most remarkable articles in the present volume, are those on the Health of Towns and the Utilization of Sewage; Military Art, including a discussion of Captain Moncrieff's invention, with account of a similar system tried in the commencement of the present century; Tromee's Electric Sound for finding Bullets in Wounds; An account of the very remarkable researches of M. Marey, of the College of France, on the Flying Mechanism of Birds and Insects; On the powers of the Picrates and other Explosive Substances; And an account of the Formation of the Suez Canal, with engravings of the machinery employed, and a panoramic view of the isthmus.

Our young readers, who desire to keep up or improve their French, will find M. de Parville's well-written and handy volumes valuable.

Principles and Construction of Machinery: a Practical Treatise for Students, Engineers, and Practical Mechanics. By Francis Campin. C.E. London: Atchley & Co., Great Russell street. For Sale by Van Nostrand.

A past president of the Civil and Mechanical Engineers' Society, as Mr. Campin is, cannot but be a fitting and competent writer on the principles and construction of machinery. Mr. Campin here treats of the laws of the transmission of power, and of the strength and proportions of the various elements of prime movers, mill work, and machinery generally. The work is the substance of a carefully revised digest of the author's oral instructions as a teacher in training pupils. He has aimed at setting forth fully the laws of construction in reference to strength of parts, while stripping the subject of much cumbrous matter with which it has heretofore been loaded. He teaches not only why a given machine produces a certain effect, but also how practically to make it. —*The Builder.*

Traite de Topographie. Par E. Maes. Librairie Militaire. Paris. For sale by Van Nostrand.

This is a well-printed volume, royal octavo, of 330 pages, containing, besides instructions in the methods of "surveying" and "levelling," complete and minute directions for mapping, reducing plans, and finally, photo-lithographing the maps.

A folio volume of thirty plates accompanies the text.

The surveying methods described are designed for military engineers, but afford excellent suggestions for railway engineers while making reconnaissances.

A Manual of Zoology for the Use of Students. By Henry Alleyne Nicholson. Vol. 1., Invetebrate Animals. London: Robert Hardwicke.

This work is well designed for thoroughly scientific instruction. The classifications are completely set forth, and the latest views and discoveries are noted.

The illustrations are abundant, although not elegant.

Volume 2 is not yet at hand.

MISCELLANEOUS.

Sir Joseph Whitworth on Street Tramways and Road-making.—The use of horse tramways is being urgently pressed forward, and a large outlay is contemplated. In Sir Joseph Whitworth's opinion, however, they are not suited to the present times, and mechanical engineers have a right to enter their protest, considering the many obstructions there have been for many years past to the employment of road locomotives. If toll gates were abolished, and each county had an organized staff for making and keeping the roads in good order, using the steam roller, steam sweeping machine, and other necessary appliances, where there is a large traffic, mechanical engineers would then, Sir Joseph has no doubt, soon produce a small light locomotive that would do its work quietly and most effectually; at the same time, pedestrians and those who ride and drive would have the great enjoyment of good and clean roads, instead of the present badly paved and rough macadam roads. The broken stones of the latter are now left for the horses' feet and narrow wheels to consolidate in a way which is quite distressing to see. The consumption of fuel per horse power is now so small, that road locomotives could be employed at far less expense than the over-worked and ill-conditioned horses we now see, while pedestrians and those who keep animals for

pleasure would have good roads, and many gentlemen, no doubt, would have their well-made locomotives. Under any circumstances, good clean roads are the most profitable when everything is taken into account; but unfortunately those who make and repair them generally consider only one side of the question.—*The Building News.*

THE SEWAGE QUESTION—LEEK.—The clean and good-looking little town of Leek promises to become, in vital statistics, a model town to the country. The sewerage works have been in existence nine years. The beneficial results have been great. The annual number of deaths in the decade ending in 1860 was 29 to the 1,000; during the last decade it was 24; and the average ages of the dead have risen from 24.8 to 32.5. Thus the average duration of life has been prolonged by nearly one-third. 492 persons are now alive in Leek, who, had the ratio of deaths in the first decade continued, would now have been dead. Those who died during the last decade lived, in the aggregate, 16,309 years longer than they would had the average age at death during the previous decade been continued. Had no sanitary improvements been made, many would have been widows and orphans whose husbands and parents are now living. There has been a corresponding decrease in sickness, the money savings of which, reckoning each case at five shillings a week for 50,752 weeks, amounts to £12,668. Of the sickness prevented 16,917 weeks are saved to the workers between 15 and 55 years of age, being a saving of £6,343 1s. 6d., even though a man's wages were only 10s., and a woman's 5s. per week. The funeral expenses saved, at £5 each, amounted to £2,460. The direct money saving was £21,491 17s. 6d., not to speak of the unspeakable advantages of every kind from improved health and prolonged life. Thus the drainage of a town not only benefits the owners of property, it benefits the poor above all persons.—*The Builder.*

FOREIGN TELEGRAPHIC NEWS.—Advices from Yokohama, Japan, to the 24th January, state that the new telegraph line between Jeddo and Yokohama has been completed—the first message having been sent over the wires January 7th. The line will be thrown open to mercantile purposes very soon.

After a lapse of some years efforts appear to have been successfully made for re-establishing direct communication between England and the Channel Islands. The Jersey and Guernsey Telegraph Company propose to lay a new cable by a shorter route than the one previously adopted, more advantageous in every respect; and they also propose to use a much stronger and more suitable cable than the one previously laid over the longer route, and which proved an expensive failure. The new cable will be laid from a point near the Start across to Guernsey, and from thence to Jersey. The longest length of the cable required by the company can be laid in one day; and as the greatest depth of water will not exceed 70 fathoms, any repairs that may be required can be quickly made. The cable has been contracted for, to be manufactured and laid within a short period, for the sum of £25,000; and a further agreement has been made with the manufacturers, who will, for the sum of £1,000 per annum, maintain the cable in perfect working order for 5 years.

To avoid the liability to interruption of the land line of 600 miles in length across the Island of Cuba, in completing the connection between the cables of the International Ocean Telegraph Company and the extensions to Jamaica and Panama, the Cuba Submarine Telegraph Company has been organized, with an exclusive concession for 40 years, for laying a Submarine Cable from Santiago de Cuba—the landing place of the Jamaica Cable, at the southeastern extremity of Cuba—to Batabanos; from thence a land line will be erected along the railway across the Island to Havana, a distance of about 30 miles; there it will join the cable to the United States. The length of the cable will be 540 miles, and will be manufactured and submerged by the India Rubber, Gutta Percha and Telegraph Works Company, for the sum of £147,000, and is to be of the same efficient description as that made for the International Ocean Telegraph Company and for the West India Company. The directors state that it is expected that the cable will be laid within the next four months—arrangements having been made with the contractors for its manufacture and simultaneous shipment with the first portion of the West India and Panama Company's cable at the end of March next, so as to connect, without delay, the terminus of that company's line with those of the International Ocean Telegraph Company.—*The Telegrapher.*

ARTIFICIAL ICE-MAKING IN THE SOUTH.—An enterprising citizen of Columbia, S. C., has ordered an ammonia ice-machine from Europe, which is to turn out 1,000 lbs. of ice an hour. It is expected to cost $9,000, besides freight from Halle to Columbia, which is several hundred dollars more. It is to be operated by a steam engine of 3-horse power. The machine ordered is the largest made by the German manufacturers, who have 5 sizes, as follows: First, the one just mentioned; secondly, one costing $6,000, requiring a one-horse power steam-engine, and turning out 400 lbs. of ice an hour; thirdly, one costing $4,000 worked by hand, and turning out 200 lbs. of ice an hour; fourthly, one costing $2,700, worked also by hand, and turning out 100 lbs. of ice every hour; and fifthly, one which is the smallest size built by the firm, costing £1,500, worked by hand, and turning out 50 lbs. of ice every hour. The cost of manufacture, including labor and material, and using the largest machine, is estimated at 9 cents for 100 lbs. of ice. Last summer the regular price of ice in Columbia was 2½ cents a lb., and at retail 3 cents. A firm in Mobile is also said to be about to engage in the manufacture of ice the coming summer.

OCEAN TELEGRAPHY.—The London "Times," in an article on Ocean Telegraphy, says it is calculated that on an average a commercial message consists of 30 words. Sixteen words per minute is the rate at which a message can be transmitted and received by skilful operators, so that 30 messages can be sent in an hour. On account of the differences of time between distant parts of the earth, there can be no division of the 24 hours into day and night, and ocean cables must be worked continuously by relays of clerks. Still, in order to allow for the intervals between the conclusion of one message and the commencement of another, the day is considered to consist of only 20 hours; in which, therefore, 600 messages can be sent or received. At the present rate charged across the Atlantic these 600 messages of 30 words

each would bring in a return of £2,700; and thus, allowing 300 working days in the year, a single cable to America might earn a possible annual revenue of £710,000.

The business done already shows that the commerce between two centres of activity will pay for telegrams at a rate which will not only render the wires very remunerative property, but must also speedily lead to the adoption of such lower charges as will enable the system to be employed far more generally than it is at present. Indeed, when the returns from the lines have paid the original cost, and left a reserve fund for repair or replacement, there is no reason why business should not be done at exceedingly low rates, and so as to draw to the cable ordinary messages of domestic news, now consigned to the mails only. The entire length of ocean cables laid and in progress, excluding short lines, is 20,961 miles, and the capital stock engaged is £6,925,000.

England is at present dependent on Russia for telegraphic communication with India, and it happens in this wise: Russia constructed a line to her army in the Caucasus. This cost largely for maintenance, and the bright idea occurred that if the line could only be extended to India, the expense of its maintenance could be placed upon the broad shoulders of British commerce. The line was then constructed by the English from the termination of the Russian one, by way of Teheran and Tabreez to Bushire, and so through the Persian Gulf to Kurrachee. It was agreed that this line should pay a royalty of 40 per cent. on its receipts for the privilege of working through the Russian wires, and the result has been not only the dependence of Anglo-Indian telegraphy upon a foreign power, but also that British subjects have paid for the maintenance of the Russian line to the Caucasus, and that the Persian line, thus burdened, has returned to its British proprietors the modest dividend of 1.3 per cent.

Another Russian military line is across Siberia and Tartary, and on to this has been "tailed" a line to Posietta, on the Japanese Sea, whereon a company, "nominally Danish," is to lay a cable to Japan and to the Chinese ports. So Russia absolutely contrives to have the English business from China pass over her wires. The London "Times" does not like this, and so urges the completion of ocean lines, to take the place of these overland.—*The Telegrapher.*

Proposed Pacific Telegraph.—The Committee on Commerce has reported without amendments the bill to encourage telegraphic communication between the eastern and western hemispheres, or, in other words, the Pacific Cable Bill. The Bill provides that the starting-point for the cable shall be south of Cape San Juan, in Washington Territory. The line which the American and Asiatic Telegraph Company originally estimated, and to which substantially, we presume, they still adhere, was about 5.000 miles long. But the islands of the Pacific offer a great advantage in breaking this long line; and in this repect the enterprise is less hazardous, so far as the establishment of the line is increased, than its Atlantic predecessors. The distance from San Francisco to Cape San Juan, in Washington Territory is 700 miles, and this part of the line is already made. There begins the ocean cable proper, which, proceeding north-westerly, finds its first station at Sitka, a distance of 630 miles. Thence, proceeding due west 500 miles. it touches Kodiak, where we have, or lately had, a military post. Thence, stretching south-westerly along the peninsula and the Aleutian group of islands 450 miles, it touches Oonalaska. From that point it leaves American islands behind, and 660 miles to the west reaches the island of Attou, and with 660 more, Urup, the latter on the Asiatic shore. Another stretch of 300 miles carries it to Hakodadi, in Japan, where its mission proper as an ocean cable may be said to end. But with a northerly move of 200 miles, it reaches Poseyat, where, on the mainland of Asia, it will connect with a branch, already built, of that great Russian overland route which continues to the mouth of the Amoor River. From Poseyat a southerly trend of 650 miles (also submarine) carries the cable to Nagasaki, whence an easterly branch may continue 600 miles to Yokohama, and a westerly one of 450 to Shanghai, the latter to connect with the East India Telegraph Company's line, so encircling the globe. These were the stations, we say, and these the distances estimated a year or more ago, and if they have been, or shall be slightly changed, it can only be in the way of improvement. Even as they are, it is clear that no distance between adjacent points in the long line is greater than 700 miles, which is a trifle in ocean telegraphy. And, again, it is clear that the strict trans-Pacific course—say from San Juan to Hakodadi, is 3,190 miles in length, while that from Sitka to Japan is only 2,490. It is evident that the project is perfectly practicable, and that it need not be long before we have daily news here in New York from Japan and China, as we have it now from England and California.—*New York Times.*

Feeding Steam Boilers.—A recent English invention for feeding steam boilers or generators with water by the use of an automatic apparatus, consists of a heating or boiling close vessel, into which the supply water is filled either hot or cold, by the mere flow or slight head of gravitation supply (without the necessity of a pump or other forcing apparatus) intermittently by a reverse siphon construction of pipe, with a regulating-valve open or allowed to open by a float falling when the water is low in the boiler or generator, and the force of the inlet water through the siphon and valve, until the feeding vessel is full, or nearly so, the water being then heated within the feeding vessel until the steam rises above or equal to the pressure of the steam within the boiler or generator, when the water would then flow or gravitate into its water-space through a pipe and valve connecting the lower part of the feeding vessel therewith.

Papier-Mache Church.—There is said to be a papier-maché church actually existing near Bergen, Germany, which can contain nearly 1.000 persons. It is circular within, octagonal without. The relievos outside, and statues within, the roof, the ceiling, the Corinthian capitals, are all papier-maché, venecred waterproof by a saturation in vitriol, lime water, whey, or the whites of eggs.—*Builder.*

It is found that a sheet of ice 32 in. thick affords a perfectly safe passage for infantry or horses, marching in single file, and for light carriages; with a thickness of 6 in. it will bear all sorts of wagons and cannon.